A COMPLETE HISTORY

OF THE

NEW YORK and BROOKLYN BRIDGE

From its Conception in 1866 *to its Completion in* 1883.

Compiled by S. W. GREEN.

WITH PORTRAITS AND SKETCHES OF THE LIVES OF

JOHN A. ROEBLING,
WASHINGTON A. ROEBLING,
HENRY C. MURPHY,
J. S. T. STRANAHAN,
WILLIAM C. KINGSLEY,
SETH LOW.

COPIOUSLY ILLUSTRATED

With Original Drawings never before Published.

PRICE 25 CENTS.

NEW YORK:
S. W. GREEN'S SON, PUBLISHER,
696 BROADWAY
1883.

NEW YORK AND BROOKLYN BRIDGE—VIEW FROM GOVERNOR'S ISLAND.

A COMPLETE HISTORY

OF THE

NEW YORK AND BROOKLYN BRIDGE

FROM ITS CONCEPTION IN 1866 TO ITS COMPLETION IN 1883.

COMPILED BY S. W. GREEN.

WITH PORTRAITS AND SKETCHES OF THE LIVES OF

JOHN A. ROEBLING,
WASHINGTON A. ROEBLING,
HENRY C. MURPHY,
J. S. T. STRANAHAN,
WILLIAM C. KINGSLEY,
SETH LOW.

COPIOUSLY ILLUSTRATED

WITH ORIGINAL DRAWINGS NEVER BEFORE PUBLISHED.

NEW YORK:
S. W. GREEN'S SON, PUBLISHER,
696 BROADWAY.
1883.

Printed, Electrotyped and Bound by
THE CHAS. M. GREEN PRINTING CO.,
74 and 76 Beekman Street,
New York.

CONTENTS.

PAGE

INTRODUCTORY 9
At last—A long time:—And yet a short—Mr. Kingsley at the plough—Act of incorporation and corporators—Assumption by the two cities—The two Roeblings—The increased cost and why—The task ahead.

THE CAISSON 15
Its many legs—The air-lock—The water-shafts—Other shafts—Compressors—Must be tight—Place for the caisson—Its berth made and occupied—The stone foundations begun—How the caisson sinks—Difficulties—Blasting—The caisson disease—A hint of the disease—A weird scene—Lighting the caisson—Accidents—"Sealing" the water-shafts—A great "blow-out"—Fire!—Col. Roebling partially paralyzed—Three months lost—Cost of the accident—The Brooklyn foundations finished—A coffer-dam—The ledge under Manhattan island.

THE TOWERS 29
Tower-building—The saddle-plates—The saddles—Good head and hand work—What next?

THE ANCHORAGES 32
Foundation of Brooklyn anchorage—Foundation of New York anchorage—The anchor-plates—The anchor-bars—The outer bars end in two fingers—The chain begun.

CABLE-MAKING 36
Come, cable!—Towers and anchorages—Getting ready for cable-making—The first rope across—Mr. Farrington first over—Other ropes—The foot-bridge—The cradles—Their uses—The great cables—The strands—The shoe—The wire—"Drumming up"—Splicing—The guide-wire—The travelling sheave—"Regulating" the wire—Wrapping the strand—"Letting off"—Temporary central cable—A strand breaks loose—Destroying the strand formation—Wrapping cables finished—Hanging the roadway—Suspender-bands and sockets—Suspender-ropes, sockets, and stirrup-rods—Floor-beams—Laying the floor—Cables below the roadway—The suspender stays—The longitudinal trusses—Prevention of lateral movement—The lateral braces—Universal stanchness.

The Pathways on the Bridge 55
The footway—The railway—The driveway—Expansion joints—Electric lights.

New York and Brooklyn, and their Environs 59
Growth of New York—Growth of Brooklyn—The tongue on which New York stands—Many New Yorkers must live outside the city—New Jersey—Staten Island—Long Island ahoy!—Travel over the old Brooklyn ferries—Ferriage difficulties—Fog—Ice—The release—The new thoroughfare—Seems like a street—The view from it—The human brain—"Bad for the coo."

The Question of Tolls 69
Two views—Foot-passengers—Footway will not be lonesome—The railway service—Tolls on the driveway—The Union Ferry Company.

The Prospects for Brooklyn 73
The dormitory of New York—Rapid transit in Brooklyn—Flatbush Avenue extension.

Future of Long Island................................ 76
"Fish-shaped Paumanok"—The Long Island Railroad—The Bridge in the railroad circuit.

Honor to Whom Honor is Due 79

Sketches of Men Prominent in the Enterprise 81

John A. Roebling	81	Henry C. Murphy	88
Washington A. Roebling	82	James S. T. Stranahan	90
William C. Kingsley	86	Seth Low	92

Statistical Items 94

LIST OF ILLUSTRATIONS.

	PAGE
The Bridge from Governor's Island	2
The Caisson, on its Downward Road	19
Top of Tower, with Saddles and Connections	29
Anchorage and Strand Fastenings	35
Mr. Farrington Crosses on the Traveler	38
Splicing Wires	43
Cross-Section of Cable	45
Wrapping Cables	48
Bridge from Below, near Fulton Ferry	54
Section of Passageways of Bridge	56
Proposed Flatbush Avenue Extension	74
Portrait of John A. Roebling	81
Portrait of Washington A. Roebling	84
Portrait of William C. Kingsley	86
Portrait of Henry C. Murphy	88
Portrait of James S. T. Stranahan	90
Portrait of Mayor Low	93

The New York and Brooklyn Bridge.

AT LAST.

The tide of travel begins to flow back and forth over the great structure which now unites the largest and the third largest cities of the Union, the Atlantic pulsating between. No longer can the impatient passenger over the East River, detained by fog or ice, look up at the slowly-growing causeway overhead, and wonder to himself and his neighbor whether he shall live to cross it, and incredulously shake his head. The old Brooklyn resident sees the task accomplished; and the long years of waiting dwindle to a moment smaller than that in which the Arabian Nights hero ducked his head in the tub of water, and experienced the vicissitudes of half a lifetime before he drew it out again, and all within the compass of a breath. How recent seems the agitation whether such a thing were possible; the various plans, bordering all the way from sober sanity to stark inanity; how of yesterday the persistent face and figure that buttonholed the traveller at Fulton and Main Streets, and would unroll his sanguine map to your indifferent gaze if you dallied with him an instant.

A LONG TIME.

Nearly twenty years have gone since the matter was first effectively agitated—more than sixteen since the charter was passed. How frequent and long the delay seemed! And yet, as all have been surmounted, even John Kelly left years behind, the time seems short for the work done. Examine, step by step, as you pass from Brooklyn to New York. From under the Bridge scan the nine hundred and thirty feet you traverse over Prospect and Main Streets to the Dock Street side of the Brooklyn anchorage. View the arches crossing each other diagonally in the bridges over the streets and in the anchorage itself. What long-continued and patient work, directed and watched by what an educated brain! As the eye roams up and down and across, inside and outside, on brick and on stone, it is perpetually called to stop and admire. And where you and I admire to the extent of our small capacity, the trained and capable engineer is filled as full of delight and wonder to the extent of his vastly greater capacity. So at the New York ends from Chatham Street, over North William and William Streets, over Rose and Vandewater Streets, over Cliff and Pearl to the Cherry Street side of the New York anchorage, more than fifteen hundred and sixty feet of the same splendid workmanship and material.

AND YET A SHORT.

And then you are only on the threshold of the wonder! From the land side of either anchorage walk across the solid masonry more than one hundred feet to the seaward side. See stretching away in the distance the cable-hung Bridge proper, suspended high in air nine hundred and thirty feet land span to the nearest tower; then more than fifteen hundred and ninety-five feet over the Atlantic Ocean, here beating back and forth in the strait misnamed the East River; and then another nine hundred and thirty feet to the other anchorage. Those four cables, each lying so airy and so graceful in its three descending loops, airy and graceful as they are, measure nearly sixteen inches in diameter each, and each of them weighs nearly nine hundred tons. And that five-tracked roadway extending from the mainland and resting on these cables, sometimes hung below them, sometimes lying directly on them, and in their lowest bends carried above them on pillars, guyed and braced in all directions; how firm it stands! how indifferent to wind and storm! Does not the wonder grow, not that the Bridge has been so long a-building, but that it has been built so quickly?

MR. KINGSLEY AT THE PLOUGH.

When, in 1865, Mr. William C. Kingsley first took fairly hold of this enterprise, and had plans and estimates made by competent men, almost the same line was recommended as the Bridge actually now occupies. This line extends from a point in Brooklyn near the junction of Sands and Washington Streets about 38½ feet above high-water mark, to Chatham Street, New York, near the City Hall, about 61½ feet above high-water mark. When afterwards permission was obtained from the United States Government to put a suspension-bridge across the river, that permission stipulated that the channel of the river should not be interfered with in any way, and that the highest part of the Bridge should be at least one hundred and thirty-five feet above high-water mark. So that the place of each terminus, and that of the highest part of the main span, were settled.

ACT OF INCORPORATION AND CORPORATORS.

The original act to incorporate the New York Bridge Company was introduced in the Senate of this State by Hon. Henry C. Murphy, Jan. 25, 1867, and passed the 16th of the following April. The charter fixed the capital at $5,000,000 to begin with, and authorized the cities of New York and Brooklyn, through their common councils, to subscribe for stock. The original incorporators were: John T. Hoffman, Simeon B. Chittenden, Edward Ruggles, Smith Ely, Jr., Samuel Booth, Grenville T. Jenks, Alexander McCue, Henry E. Pierrepont, Martin Kalbfleisch, John Roach, Charles A. Townsend, Henry E. Stebbins, Charles E. Bell, Chauncey L. Mitchell, T. Bailey Myers, Seymour L. Husted, William A. Fowler, William W. W. Wood, Andrew H. Green, Edmund W. Corlies, William C. Rushmore, Ethelbert S. Mills, Alfred W.

Craven, Arthur W. Benson, T. B. Cornell, John W. Hayward, Isaac Van Anden, Pomeroy P. Dickinson, Alfred M. Wood, J. Carson Brevoort, William Marshall, Samuel McLean, John W. Combs, William Hunter, Jr., John H. Prentice, Edmund Driggs, John P. Atkinson, and John Morton.

ASSUMPTION BY THE TWO CITIES.

But as the work progressed a feeling of jealousy arose against the control by a private company of the public moneys voted by the two common councils; and June 5, 1874, an act was passed by which the two cities assumed the Bridge, paying back to the original subscribers the amount of their subscriptions, with interest; and the management was put under the control of a board of twenty trustees, ten from each city, including its mayor and comptroller. The funds were raised, two thirds by Brooklyn and one third by New York. The working staff of the Bridge and its managing minds have remained substantially the same from the start.

THE TWO ROEBLINGS.

The company organized in May, 1867, and John A. Roebling was appointed engineer May 23. He made his plans and estimates, and submitted them the next September. But in 1869, while standing on the Fulton Ferry Dock fixing the location of the Brooklyn tower, a ferryboat, colliding with the side of the slip, caught and crushed Mr. Roebling's foot. He died a little more than a fortnight after this accident, July 22, 1869. His place was taken by his son and associate, Col. Washington A. Roebling, and under his management and oversight the work has been completed.

THE INCREASED COST, AND WHY.

The original figures have been largely exceeded. At the beginning, the elder Roebling estimated that the bridge could be built in five years, for $7,000,000, exclusive of the land. The land cost about $3,800,000, making, as originally estimated, $10,800,000 for Bridge and land. But the work has cost about $15,000,000, nearly $5,000,000 more, and has taken more than twice the time. The original estimated height was 130 feet, to which the United States Government added 5 feet. The original estimate was for a width of 80 feet. The Bridge was made 85. For the New York tower a foundation had to be sunk to nearly double the depth originally estimated. Then the suspended structure and the cables carrying it have been made of steel instead of iron. The approaches, too, are solid mason-work, with many desirable fire-proof stores to let in their arches, instead of passing over on trusses, as first intended. This also necessitated the buying of property not originally contemplated. One building in Frankfort Street cost the Bridge more than $100,000 purchase-money, besides the expense of taking down six fire-proof stories. Station-houses, "incidentals," law expenses, discounts, and delays have also counted up. The work stood still for months, owing to the refusal of John Kelly, then Comptroller, to furnish New York's part of the funds; and the Trustees had to carry the case to the Court of Appeals before they could get the money to which the court of last resort said they had all along been entitled. These very delays have been of unexpected and enormous advantage to the solidity and permanence of the Bridge. But for that occasioned by Mr. Kelly's obstruction, and carrying the case through the courts, iron would have been employed as at first intended. Before building was resumed, methods were discovered of constructing in steel what before was not possible in that substance; and these methods were utilized when the work upon the Bridge was again taken up.

THE TASK AHEAD.

But let us go back again to the beginning. To carry this projected roadway 135 feet above mean high-water mark, a tower must be built on each side the river so high that the cable may droop from the top of each, and the loop in its centre rest this 135 feet above the river. And through these towers must be openings for the roadway to pass, gently rising from each end to its extreme height, the supporting cables gracefully curving down and the suspended roadway as gracefully curving up. It was decided that the floor of the openings in the tower through which the roadway must pass should be 119 feet above high-water mark, the top of the tower over which the cable must pass should be 159 feet above the roadway, and the total height of the tower above high-water mark nearly 277 feet. And it was decided that each tower must be 140×59 feet at high-water mark, gradually drawn in to 136×53 feet at the top. On what shall this enormous mass of masonry rest? And how shall its foundations be firmly laid beneath the waves of the ocean surging through the East River?

THE CAISSON.

The plan almost necessarily selected was that of the caisson, a French word meaning chest. As here used it is an enormous box or trunk, large enough to underlie the 140×59 feet of the tower, and strong enough to carry this tower on its back. In a ship-yard it is built; some of the timber courses, however, not being put on till it is in position. The Brooklyn caisson has a top 15 feet thick, of solid yellow-pine beams, each one foot square, laid in courses at right angles to each other, the whole mass being bolted together in the strongest possible manner. Its size from edge to edge is 168×102 feet—a little larger than the base of the tower. This great mass rests on four sides, each 9½ feet high, 9 feet thick where they join the top, and tapering like an italic *V* to an edge of six inches, shod with thick cast-iron rounded. So that this mammoth Saratoga trunk has no bottom, an inside 9 feet high, with sides tapering to its no bottom, and a lid 15 feet thick, which won't open. What an oyster for a typical baggage-smasher!

ITS MANY LEGS.

But heavy as our lid is, it cannot be trusted to carry the foundations on the sharp edges of its sides. Across the 102 feet run five timber partitions 2 feet thick, strong and well braced, dividing the 168 feet into six compartments. And in each of these partitions are two openings, high and wide enough for a man to push a barrow through. What Frankenstein can grasp this mighty box, put it flat on the bottom of the river, hold it with one hand, while with the other he wields a gigantic straw, perforates to the inside of the "Saratoga," and, with his huge lungs, blows in the air till the water is driven out below the cast-iron shoes, so that, protected by his mighty breath, crowds of pigmies may go down cellar and work? And if he can only keep the cellar clear, get the pigmies out and in, and remove the débris their picks and shovels and barrows make ready, into the bowels of the earth he can sink the cellar till he comes to bed-rock. The Frankenstein was called, and came.

THE AIR-LOCK.

Provision had to be made through the lid of this trunk, the roof of this caisson, for various things, and as it was built up in the ship-yard the necessary shafts or tubes were put in. Two were for the entrance and exit of men. They were round, and to the top of each was bolted an "air-lock," a wrought-iron cylinder seven feet high by six and a half feet in diameter, and at each end a valve or door large enough to pass the body of a man, each door opening downwards. Ladders reached from the top of the shaft to the bottom of the cellar. Near the lower door was a valve opening into the cellar. On entering the air-lock from above the upper door was closed by a rope and pulley, and the valve into the cellar opened. As soon as the compressed air, or giant's breath, had equalized itself between the cellar and air-lock, the lower door dropped open, and the ladder gave admission to the working chambers.

THE WATER-SHAFTS.

Two more tubes were called "water-shafts," and were used for the removal of the débris dug and blasted from the cellar. They were about the same size as the entrance-shafts, though those in the Brooklyn caisson were not round, but rectangular. They were let down into open pits in the ground dug below the level at which the water was held by the compressed air. As the water in these pits stood at that level the compressed air was locked out of them, and whatever was excavated and dumped by the miners into these pits fell to the bottom. A dredging-machine operated through each of the shafts into these pits, on the same principle as those we see at work in slips and the harbor, and their iron fingers clawed up from the bottom whatever was there "dumped," rose with their load to the surface, and deposited it in the attendant scow.

OTHER SHAFTS.

Other tubes called "supply-shafts" were made, through which the caisson might be filled when it reached its permanent bed. Smaller pipes were put in to supply gas and water, and to blow out sand by air-pressure. Of course, as the masonry was afterwards built on, these shafts were kept open through it.

COMPRESSORS.

Compressors or air-pumps were set up in a building on shore, and connected with the interior of the caisson by means of a large cast-iron pipe laid underground, and by rubber hose. Through these the Frankenstein could blow the water out.

MUST BE TIGHT.

It stands to reason that all this structure must be made water-tight. Between the timbers of the lid were metal plates, and joints were at first calked with oakum. The compressors have enough to do to drive the inevitable weight of water from the cellar, and must be spared any unnecessary work.

PLACE FOR THE CAISSON.

Let us go back to our caisson in the ship-yard, finished as described above, resting on ways, ready to be launched. Meanwhile the place where it is to be sunk has been made ready. The work in which the elder Roebling lost his life has been completed by others. The spare slip at Fulton Ferry on the Brooklyn shore has been removed, and the bottom levelled off so as to get a depth of 18 feet clear water. This has been no easy task. Part of the

2

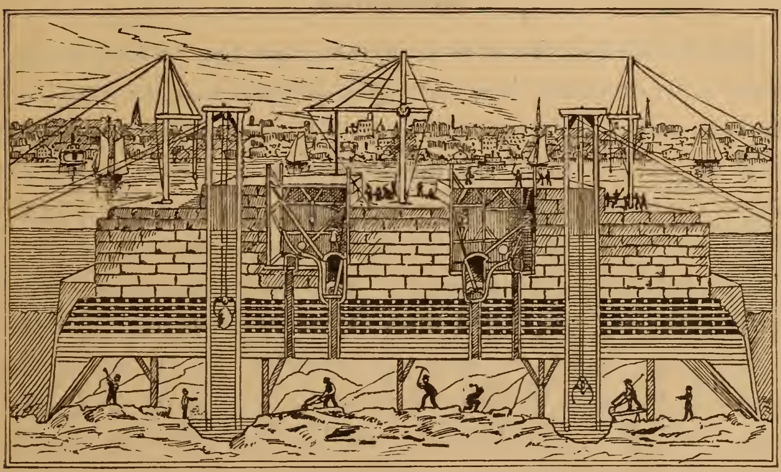
river bed here was a compact mass of sand, clay, and bowlders, so cemented together that the dredge was useless. Wrought-iron piles six inches in diameter had to be driven in, drawn out again, the holes they left filled with cast-iron canisters carrying heavy charges of powder, and fired by electricity. This done, the dredges could clutch and remove the débris the explosion had left, and at last the 18 feet of depth is cleared.

ITS BERTH MADE AND OCCUPIED.

To fix the position of the caisson, a row of piles and sheeting is driven in, 168 feet along the shore line, and at each end another row 102 feet long, at right angles to the first, thus forming a pew or pen open on three sides for the admission of the caisson, into which it is towed, and then the remaining side, 168 feet again, made in the same way. To help buoy the caisson in its transit from the ship-yard to its place, heavy as it is, a force-pump is erected on its deck and compressed air driven in. The great chest is now floating in the water, held in on every side by its encompassing fence of piles. The engineers determine its place with extreme nicety, and fix and fasten it there by blocks and wedges, and here it rises and sinks with the tide. Three large derricks, each with a ten-ton lift, are erected in the caisson so as to reach all parts of the work, and tracks are laid to bring the stone from the dock to the derricks.

THE STONE FOUNDATIONS BEGUN.

Now begin the foundations of the stone pier that is to be on the top of the caisson. The great squared blocks, limestone inside and granite outside, brought on the tracks and lifted by the derricks, are lowered one by one into place, until, the first course laid complete, 140 feet long and 59 feet wide, the monster caisson has settled with its load, and does not rise as high with the flowing tide as it did. By and by the added blocks sink the caisson till it settles to the bottom, and there remains, its top still visible above water. The compressed air is pumped into the interior of the caisson and drives out the water, forcing it under the iron-shod edges. Engineers and workmen can now go down, trim the earth level under the edges, and finally adjust and fix the mass in its exact place, supporting it uniformly by blocking placed under its five cross partitions. A little more limestone on the top, and the mass has become practically immovable, and the work of sinking the caisson is fairly under way.



THE CAISSON, STARTED ON ITS JOURNEY DOWN.

HOW THE CAISSON SINKS.

The laborers with pick, shovel, and barrow feed the dredges with the mud and stones they dislodge. When the earth has been sufficiently removed, the workmen drive out alternate blockings from under the partitions on which the mass rests, leaving its weight on the remaining blocks, which slowly settle a little under the load, and in the most uniform manner. The earth is levelled, and the blocks before removed are again tightly driven in. Then the other blocks, the first time untouched, are driven out, and in the whole operation the caisson has gone down about an inch. The weight and strength of the caisson and its load are so enormous, that any little difference in the density of the cellar bottom, or in the driving of the blockings, is irresistibly equalized, and the mass sinks inch by inch as the process is repeated, plumb down. Of course, care is perpetually taken that no bowlder or other obstruction be left under the descending shoe of the caisson's edges, and no pains are spared to remove any cause that may seem to tend to deflect the perpendicularity of the descending mass.

DIFFICULTIES.

But for all that, the work is anything but easy. Often the material to be excavated is so hard and compact that the picks and shovels cannot disintegrate it, and steel bars specially prepared have to be driven in, and small portions at a time picked off. Bowlders turn up, in the most unfortunate places, from 1 to 250 cubic feet in size, sometimes of trap-rock, sometimes of quartz or gneiss, sometimes of sandstone. Men constantly probe under water with iron rods to find these hidden obstructions, to prevent the caisson settling on them to its possible injury, and to the certainly increased difficulty of their removal under its weight. Sometimes even winches and hydraulic jacks are ineffectual to remove the stones from under the edges and the partitions. Bowlders have to be undermined and rolled into the caisson, and there separated by drills and wedges. At first, owing to various such difficulties, the caisson settled only six inches in a week—a rate which would have taken more than a year and a half to sink the Brooklyn caisson, and about three years for the New York one. And the wear and tear of tools is enormous.

BLASTING.

Can powder be used in blasting? There is no previous experience. What will be the effect of concussions on the ear? Will they rupture the tympanum? Will the smoke become suffocating? Will not the concussions break the valves and doors in the air-locks, let out the air, and admit the water? Who knows? The experiment is made, beginning with the firing of a pistol, trying light blasts and then heavy ones, but with none of the dreaded results. So blasting becomes a part of the programme, holes being sometimes drilled completely through bowlders under the edge, the charge inserted at the bottom, and they loosened or thrown into the caisson. At these explosions the workmen easily step from that compartment into another of the six. The work goes on day and night, by relays of men called "shifts" working eight hours each. They are provided with dressing and eating rooms above ground, and every means used to secure their health and comfort, and to push on the work.

THE CAISSON DISEASE.

For, with all the discomforts and exposures of working and blasting so far under water and the ever-present dread of submersion, another great danger arises from living in the compressed air—the danger of the "caisson disease." In the Brooklyn caisson the highest pressure was 23 pounds to the square inch, besides the normal atmospheric pressure. In the New York caisson at one time the pressure was 34 pounds. The symptoms of this caisson disease are cramps and severe pain in the joints, paralysis, and sometimes death. On entering a caisson through an air-lock under high pressure a severe pain in the ear is usually felt till the pressure is equalized. To some the pain is insupportable, while others are hardly inconvenienced. Putting fingers or cotton in the ears is unavailing.

A HINT OF THE DISEASE.

Any boy or man in the bathing season, who can swim, may easily find what this "caisson disease" is like. Turn over a heavy boat in deep water, dive, and come up head under the boat. How your ear begins to sing, and how unpleasant the sensation is! Now try to shout aloud, and see how hard it is to make your voice heard, and how unearthly it sounds. That is a hint of the state of the atmosphere in a caisson, bearing a resemblance to the real thing such as a twinge in the toe bears to well-developed gout, or a chance cough to settled influenza.

A WEIRD SCENE.

"Inside the caisson," says Mr. E. F. Farrington, the master-mechanic of the Bridge, "everything wore an unreal, weird appearance. There was a confused sensation in the head, like 'the rush of many waters.' The pulse was at first accelerated, and then sometimes fell below the normal standard. The voice sounded faint and unnatural, and it required a great effort to speak. What with the flaming lights, the deep shadows, the confusing noise of hammers, drills, and chains, the half-naked forms flitting about, with here and there a Sisyphus rolling his stone, one might, if of a poetic temperament, get a realizing sense of Dante's Inferno. One thing to me was noticeable—time passed quickly in the caisson." It was no place for men subject to heart or lung disease, or enfeebled by age or intemperance. But a man of good health and physique, with sound head, heart, and lungs, temperate in all things, and observing a few simple rules, had no difficulty in working under a pressure of 30 or 40 pounds.

LIGHTING THE CAISSON.

The lighting of the caisson was a work of no little difficulty, and the subject of many experiments. Calcium-lights, coal-gas lamps and candles were tried. The calcium-lights worked well, but were costly. Oil-lamps smoked, and were dangerous. Candles were all along used more or less. The regular gas from the street mains worked best of all, though it increased the temperature about fifteen degrees. Of course the usual street pressure was not enough at that depth, and had to be increased. And there was constant danger of explosion from leakage, which under the high pressure the sense of smell did not detect. Fourteen calcium-lights and sixty burners were put in, but they were not all used at the same time. How Edison, or one of his kind, was needed!

ACCIDENTS.

Such a work as the sinking of a caisson could hardly be expected to be accomplished without accidents. The body of compressed air was always trying to escape. Before the caisson became firmly fixed, it was liable to tilt a little and thus set free a portion of the confined air, which in its escape would send up a large column of water thirty to sixty feet high, flooding a part of the top and stampeding the workmen. But they had due warning in a roaring noise which accompanied the rise of the water. Inside the caisson the roaring was heard, and with it came a draught of air toward the place of escape. Sometimes the wave of a passing steamer would disturb the equilibrium, and cause a "blow-out." Now and then a workman caught a fish thrown up in the column of water.

"SEALING" THE WATER-SHAFTS.

As the caisson slowly sunk to its destined bed, this cause of disturbance disappeared. The mass could no longer be tilted. But the added pound of air-pressure for every two feet of tide-water incessantly pushed to get out. The "sealing" of the bottoms of the water-shafts, into which the debris was thrown ready for the grasping fingers of the dredge, had to be kept up by means of hose, and dams to be maintained about the bottom of the shaft to keep the pool high enough to prevent the escape of the compressed air, and these dams were liable to be washed away by a change of pressure. Sometimes the bottom was so hard that a dredge could not keep its well-hole deep enough. Then the dredge was withdrawn, an iron cap bolted on the top of the shaft, and heavy stones piled on until the weight was enough to resist the air-pressure. Compressed air was forced between the cap on the top of the shaft and the water under it, the water driven downward into the caisson, and the well-hole pumped or bailed out, and deepened. When this was done, water was re-admitted, and the dredge set at work again. While one shaft was thus "laid-up," the other kept at work. Over and over again this happened.

A GREAT "BLOW-OUT."

One unfortunate Sunday morning, a neglect on the part of the watchman inside the caisson allowed the air to blow out, creating a panic and stampede above ground, and flinging over buildings and shipping a coat of yellow mud. The weight of the caisson at this time was nearly 18,000 tons. The noise was terrific, and mud and stones flew to a great height. People near the Ferry fled away from the supposed danger, and those farther off rushed down street to see what was the matter. The whole mass, caisson and masonry, settled ten inches, the shoe was crushed in places, and the center of the roof settled about four inches.

FIRE !

The Brooklyn caisson caught fire several times, and twice the interior had to be flooded with water to extinguish it. The last fire was discovered December 2, 1870. A laborer had carelessly placed a lighted candle near a joint in the roof, whence the flame was drawn in contact with the oaken calking of a timber joint. This kindled, and under the great pressure the fire made its way into the interior out of sight. The pressure being outward, no smoke or flame inside revealed the presence of danger. How long it had been burning cannot be told. It was discovered by the appearance of a large hole directly over one of the supporting partitions and near an opening from one chamber to another. Carbonic-acid gas, water and steam were applied hour after hour, till water flowed back into the caisson, but auger-holes into the roof showed that the fire was still burning, and there was no alternative but to flood the caisson. The caisson was too deep to be filled by the previous method of reducing the air-pressure and admitting the sea-water under the shoe. A general alarm was sounded, the fire department came, and in a little while thirty-eight streams of water were running into the mouths of the shafts, in addition to the water flowing from the pipes used in the caisson. In five hours and a half the caisson was filled, and the water poured out of it from the mouths of the shafts. The air-pressure was gradually reduced as the water flowed in, so that the sustaining power of the water replaced that of the air, so as to prevent straining or injury. Under the heavy weight of stone, any carelessness here might have resulted in permanent injury to the tower.

COL. ROEBLING PARTIALLY PARALYZED.

While this danger was imminent Col. Roebling, the engineer, was first partially paralyzed by the caisson disease. He was inside from 10 P.M. till 5 A.M., and returned at 9 A.M. From this attack he never has recovered, and probably never will. But his directing mind was not paralyzed, and even from his sick-room his oversight has never flagged.

THREE MONTHS LOST.

After thus flooding the caisson the water was left in it two days and a half and was then forced out of the water-shafts by air-pressure in six hours. Nearly three months were consumed in making repairs, the work going on night and day. First of all, liquid cement had to be injected into the burned openings to prevent the escape of air, partly by air-pressure and partly by a stuffing-machine made for the occasion. Then large openings had to be cut through two and three courses of solid timber to get at the burned portions and make the necessary repairs. These timbers had to be bored across and split with bars and wedges, and all burned pieces as well as injected cement had to be taken out, and the cavities scraped clean. What a job of dentistry!—the cavity worm-eaten by the erratic wandering of the fire over a space of fifty feet square. Then came the plugging: done where possible with timber strapped and bolted, and in the smaller places with concrete, made of cement, sand and gravel. The workmen had to crawl and work in all sort of uncomfortable positions, lighted by little bull's-eye lanterns, in an air full of coal and cement dust and smoke. But at the end of the three months, all the difficulties were surmounted, and the roof of the caisson as strong as ever, perhaps even stronger.

COST OF THE ACCIDENT.

After this experience with the Brooklyn caisson, that for the New York tower was built so that there was no calking that could again open the way for a similar disaster. It was lined throughout with thin boiler-plate iron. The fire had cost $15,000, and the lining of the New York caisson cost $20,000.

THE BROOKLYN FOUNDATIONS FINISHED.

The bed on the Brooklyn side being a tenacious conglomerate of clay, sand and bowlders, reaching far down, at forty-four and a half feet below high-water mark, the Brooklyn caisson was allowed to make its final halt. Under its lid seventy-two brick piers, each about five feet square, were erected, and the caisson rested on them as the temporary wooden supporting partitions were removed, and the air-pressure withdrawn. Then the whole interior was filled in with concrete and the broken stone formerly sent up from under the caisson. This was most carefully done, beginning around the shoes and working inwards, in layers six to eight inches thick, and each allowed to harden before the next was put on, the air-locks being filled last of all. The water-shafts were cut square with the roof inside the caisson, and all the braces of the supporting frames removed. When the caisson was filled up to the ground-level, the cofferdams around the different shafts removed, and the air-locks taken off, the foundations were solid and permanent, ready for the weight of the tower and cables, with their load.

THEIR ASSURED SAFETY.

So that the towers of the Bridge rest at bottom on courses of solid yellow pine, and under them brick pillars. Will not the wood decay? Experience shows that wood when thus sunk beyond reach of air and changes of temperature, is perfectly incorruptible. Oxygen is the great decomposer or destroyer. But as these timbers are placed, it cannot use its teeth, and the wooden lid of the Saratoga trunk may be trusted to remain sound and intact as long as wanted. The sea-worms were kept away by an unbroken sheet of tin outside: and below the bottom of the channel they do not pierce. The foundations are safe.

THE NEW YORK CAISSON.

On the New York side the caisson had to be sunk to a much greater depth than the first:—to 78½ feet below high-water mark, to the underlying rock. It was of the same width, 102 feet, as its sister, but four feet longer, 172 feet. Its lid was made twenty-two feet thick, while the other was only fifteen. A greater air-pressure was required for the greater depth, and thirteen compressors were used in New York, though never all at once. The work of excavating in New York was not so hard, but much more disagreeable. The first layer was sewage and sewage mud—inodorous under water, but when excavated under low pressure in the caisson—faugh! Next came clean gravel, and sand, with an occasional bowlder,—much of the sand so fine as to be forced out through iron pipes by air-pressure.

A COFFERDAM.

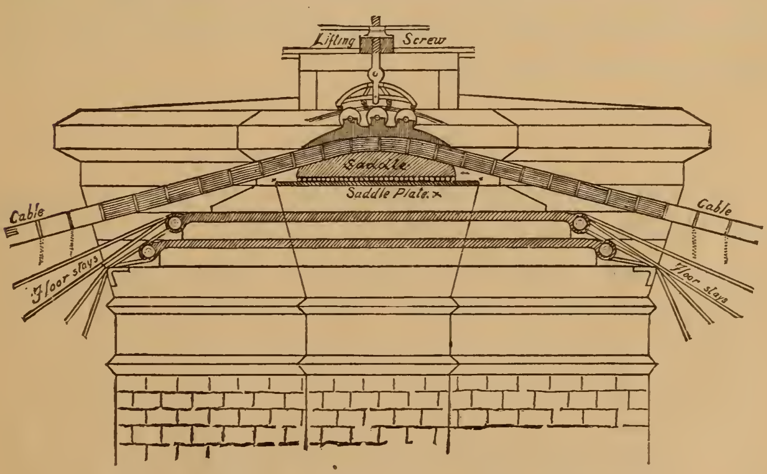
Here a cofferdam was necessary to give buoyancy and steadiness to the caisson, which required seven courses of masonry to hold it on the bottom at high tide. It commenced on the fifteenth course of the caisson roof-timber, and was made with foot-square yellow-pine posts set four feet apart and sheathed with six-inch white-pine plank, calked to keep out the water, and braced. Concrete was put between this cofferdam and the sides of the caisson, and the roof concreted three feet to keep off the worms. Into this filling excavated sand was blown as wanted, the pipes discharging against granite blocks placed above them, the sand striking these and falling back. Sand was also loaded into scows, an elbow changing the current into the scow, the elbows lasting only a short time. The foot of a pipe reached into the caisson, and a valve regulated the draft. Ten or a dozen men could not shovel in as fast as the current would draw out.

THE LEDGE UNDER MANHATTAN ISLAND.

When the New York caisson made its final halt, it was near the ledge which runs under Manhattan Island. Jagged points of rock lifted here and there, and it was "salted with quicksand." The ledges of rock under the southerly end were leveled off, a wall of concrete outside the shoe shut in the quicksand, the inside of the caisson was filled with concrete as in Brooklyn, and the New York tower also rested on a firm and permanent base.

THE TOWERS.

THE remainder of the tower-building is all above ground—some of it certainly a long way above ground—and comparatively simple. In each tower course after course is laid up to the level of the flooring of the future bridge, 119 feet above high-water mark. Just below this level heavy bars of iron are inserted in the



TOP OF TOWER, SHOWING SADDLES AND CONNECTIONS.

masonry from face to face of each tower, with great eyes formed in their ends at each corner of the tower, to hold one end of the floor-braces. Here the tower divides into three piers, leaving between them two openings, each of 33 feet 9 inches. The three piers join again into one tower, leaving these openings 117 feet high to the tops of the arches over them. Across each opening, at the spring of the arch, run four heavy iron rods or bars attached to eyes in either wall, and their length adjusted by screws, parallel to each other in a horizontal plane, for the further strengthening of the tower under its enormous load. Up again rises the solid tower nearly 40 feet above the arches. Near the top heavy iron bars run across the towers through the masonry, furnished with eyes at each end to receive the tops of the suspension braces.

THE SADDLE PLATES

Above these each tower receives four sets of iron bed-plates or "saddles," one for each cable, resting each on its "saddle-plate." Each saddle-plate is a casting 16 feet 2 inches by 8 feet, and supports one of the saddles on which the cables rest. Each is furnished with a broad groove in which the saddle-rollers are confined. They are placed on each tower, two over the centre pier, and one over each outer pier.

THE SADDLES.

The saddles are 13 feet long by 4 feet 1 inch wide, and 4 feet 3 inches in extreme height. They lie lengthwise under the cables, resting each on a series of wrought-iron rollers, running in the broad groove of the saddle-plate. The top of each saddle is curved to give an easy bearing for the cable, which is to lie in a groove 17 inches deep and 19½ inches wide. This arrangement relieves the towers themselves from direct straining or chafing of the cables under unequal loads, high winds, and changes of temperature during which the cables will lengthen and shorten. Above the saddle-plates the tower rises again 5 feet, so that the saddles and saddle-plate may be covered from the weather, and yet be easily accessible.

GOOD HEAD AND HAND WORK.

With what talent and skill all this work has been planned and watched, and with what care and faithfulness it has been done, let the completed towers testify. In the New York tower there are nearly 47,000 cubic feet of masonry, and in the Brooklyn one more than 38,000 cubic feet. And yet neither of them, one 350 feet, and the other 316 feet from base to peak, has settled two inches!

WHAT NEXT?

Now, the two towers standing high in air, ready to receive the cables and the roadway, what is the next point of interest? A suspension-bridge is made up of towers or piers to lift and carry the cables, anchorages, or fastenings for the cables at either end, and the suspended superstructure. We have taken the towers first in order, as they were first in the order of time. But neither towers nor anchorages are of any use, either without the other, and they will all be needed at the same time, when cable-making begins. And the anchorages are ready when the towers are. Let us go back to them.

THE ANCHORAGES.

Each end of each cable must be fastened so securely that the weight of cable and superstructure, together with all that can by any possibility be piled upon the roadway, and all violence of the wind, shall be unable to start the fastening a hair. And over even all this there must be the amplest margin for security. Sometimes there are rock foundations to which the cable can be attached, as there will be in the projected "Storm King" bridge over the Hudson. But here the lack of such natural rock must be artificially supplied. This is done in the two anchorages, each of which is a mass of stone 129 by 119 feet at base, 117 by 104 at top, 85 feet high in front, and 80 feet in rear. What it is most wanted for is its weight; and this is 60,000 tons, or about 120,000,000 pounds. The top of each also forms a part of the approaches which on either shore end upon the anchorages.

FOUNDATION OF THE BROOKLYN ANCHORAGE.

The masonry of the Brooklyn anchorage rests on three courses of yellow-pine timber, one foot square, the same size as comprise the roof of the caissons. The soil here is sand and gravel entirely. A pit a little larger than the foundation had to be excavated, and the tides held back by heavily supported sheet piling. A wire rope was run from the roadway of the tower to a timber in the ground 250 feet distant. To the foot of the incline thus made the sand-box was drawn from the excavation and hauled up by steam over the sand heap, and automatically dumped. This sand was admirably adapted for building purposes, and the enormous heap thus formed was afterward all absorbed in the masonry. The yellow-pine timber made an even foundation, and laid as it is below the water-level, amid springs, it will be always covered and saturated with water, and cannot decay.

FOUNDATIONS OF NEW YORK ANCHORAGE.

But in New York the anchorage "ground" lay in the outskirts of "the Swamp." The water flowed in so fast that it took three steam-pumps to expel it, working a whole month at the rate of 600 gallons a minute—more than 86,000 gallons a day. The original surface shelved outward. Under the solid foundations of the demolished buildings an old dock was found, showing where the water-line once was, and that over all this neighborhood the tide then freely ebbed and flowed. And before a trustworthy bottom could be reached, quantities of black, unwholesome mud and refuse of old tan-pits had to be taken out of the way. But here, as on the other side, the anchorage foundation was at last ready.

THE ANCHOR-PLATES.

At the bottom of each anchorage, in the rear, on the York Street side in Brooklyn, and on the Cherry Street side in New York, firmly imbedded in the masonry, are the four anchor-plates. These are of cast-iron, oval in shape, 16 feet by 17 feet 6 inches, not solid, but with radiating arms, 2 feet 6 inches through the centre. They weigh 23 tons each. If they were solid, the weight would be greatly increased, but hardly the strength. The weight of the masonry is upon them, and their office is merely to spread out their fingers and clutch under the ponderosity of the whole mass. Through the centre of each plate are two tiers of oblong openings to receive the two lower sets of anchor-bars. These go through the plates, and are secured beneath by round wrought-iron pins, five inches thick, which pass through holes in the end of the bars.

THE ANCHOR-BARS.

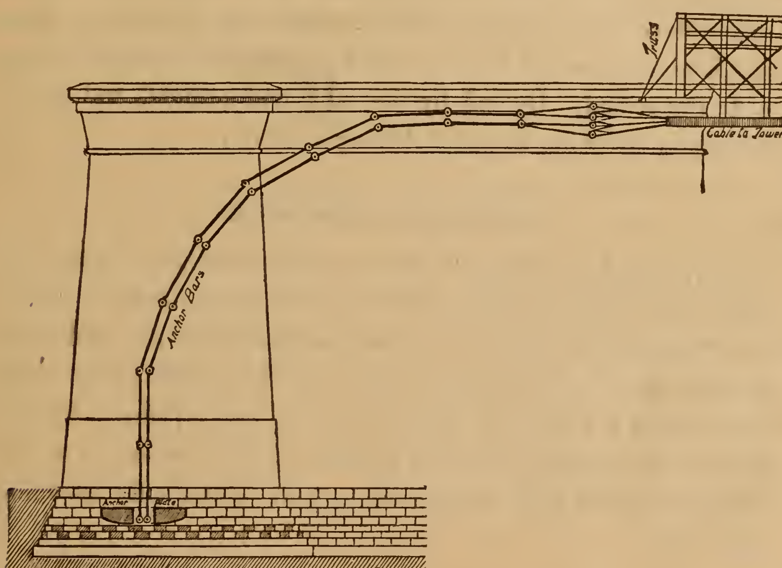
The anchor-bars are of wrought-iron, each strand needing a chain of them. There are 19 strands in each cable, so there are 19 sets of anchor-bars, each chain being 12 bars linked together. The lower bars, nearest the anchor-plate, are 3×7 inches, and as they reach upward and outward to the cable the size increases to 3×9 inches. Their average length is 12 feet. So that between the cable and its anchor-plate are these 19 chains, each 120 feet long, linked by wrought-iron bolts increasing from 5 inches thick at the anchor-plates where the pull is least, to 7 inches at the outer ends where the cables are attached and the pull is greatest.

THE OUTER BARS END IN TWO FINGERS.

The outer link of each of these chains is made double, each of half thickness; so that two bars, each $1\frac{1}{2}$ inch thick, hold each one of the 19 strands which form the cable. These double bars are the longest of the chain. The ends of all bars are made round, and nearly of double width, and holes drilled in them to receive the connecting-pins. The chains are laid in two series, one over the other, ten in the lower series and nine in the upper. The connecting-pins are turned shafts of wrought-iron, and are five feet long, a whole series of bars being pinned together at the end of their links. The higher or outer series rests at the joints on the inner or lower series, and cast-iron plates are laid between the two to give them an even bearing. These joints or knuckles rest on granite, not limestone.

THE CHAIN BEGUN.

The anchor-plates being laid at the bottom of the anchorage, the two rows of links or anchor-bars, 19 in all, are sunk through the openings in the anchor-plates, put in exact line, and the five feet long wrought-iron pins or bolts passed through each line. Then they are braced in an upright position, and the mason-work is built up around them over the whole anchorage. Next, the second set of parallel links are set in place, their eyes brought again in line with the eyes of the first set, and the next pair of heavy bolts passed through, the cast-iron plate having been first introduced between the joint of the two series. These also are held upright, and the mason-work again laid over the whole 129×119 feet. Then come the next set, adjusted in the same way, except that they are made to incline slightly forward toward the river, and again the mason-work incloses them. The succeeding sets of 19 links each



AN ANCHORAGE.

incline further and further forward, until the ninth set lie horizontal almost on the top of the anchorage; and the tenth, the bifurcated set, extend their 38 fingers straight forward, ready to clasp and hold, each pair of them, one of the 19 strands which make the cable. Thus the 19 strands of each cable hold to the concealed anchor-plate at each end through the masonry by 11 links; and the number of links in the two anchorages is 1672, held in place by 192 of the forged 5 feet long bolts.

CABLE-MAKING.

COME, CABLE!

THESE foremost links of the chain from the anchor-bars fall short of the front of the anchorage about 25 feet. Their open fingers beckon the cable to meet them there. Between each pair of fingers they hold a "shoe" of cast-iron, with a groove in its circumference to fit the strand. By and by the cable will respond, and find a permanent fastening in the sheltering masonry.

TOWERS AND ANCHORAGES.

Now, what have we got? Two massive anchorages, facing each other from opposite shores, and two towers rising between, high in air. The first are ready to take and securely hold the cable ends, and the latter equally ready to hold up the weight of the cables and whatever they may carry, over the saddle-plates. For the weight of the Bridge that is to be must not pull the towers inward, but must merely rest on them while held by the solid fastenings of its ends.

GETTING READY FOR CABLE-MAKING.

But where are the cables? Where is any one of the four we need? They are to be made in the air. We have finished our work under the tides, and now have an even more delicate task before us, and one that must be performed at a dizzy height. But first of all connection must be made between the anchorages over the towers. Before cable-making can begin, 19 temporary galvanized steel wire ropes have to be stretched across from anchorage to anchorage.

THE FIRST ROPE ACROSS.

The first of these ropes was taken across Aug. 14, 1876. On a scow carrying a wooden axle in a frame, was coiled a three-quarter-inch wire rope. From the foot of the Brooklyn tower one end of the rope was hoisted over the top of the tower, and lowered down its inner face. A manilla rope leading from an engine on the anchorage was made fast to the wire rope, and by this means its end was drawn to the anchorage, and temporarily fastened there. Next, the scow was towed over to New York, the wire uncoiling and dropping to the river bottom. At the New York dock the remainder of the rope was unreeled, the end hoisted to the top of the tower, carried over, let down the other side, and fastened to the drum of an engine used for hoisting stone. When the river was clear, the engine was started, and the rope was lifted from the water to about the height of the roadway. Then another rope was taken over in the same way. The two ropes were stayed on the New York tower, and the ends taken to the New York anchorage. At each anchorage the ends were now spliced together around the guiding and driving wheels. In this way an endless rope was formed, capable of being worked back and forth, to draw and carry loads, running on cast-iron sheaves on the saddles at the tower tops. Another endless traveller was made of two other ropes carried over on the first.

MR. FARRINGTON FIRST OVER.

The first traveler-ropes were spliced and put in running order August 25, 1876. Mr. E. F. Farrington, the master-mechanic, was the first to cross the river. A boatswain's chair—a board slung at the four corners by ropes uniting in a ring overhead—was attached to the traveler at the Brooklyn anchorage, and Mr. Farrington took his place in it at 1 o'clock P.M. on that day, and was drawn across to New York, his chair being lifted over the towers; the time from anchorage to anchorage, 22 minutes. Thousands


First
Crossing
on the
Traveler.

of people witnessed the transit, and public attention was wonderingly fixed on the exploit. But the story that the ovation he received was a surprise to Mr. Farrington, needs modifying by the fact that the crossing was known to "reporters" and announced in advance, and the time and direction taken directed by President Murphy.

OTHER ROPES.

Other ropes needed in construction were, a carrier, $1\frac{1}{4}$-inch diameter; 3 cradle ropes, each $2\frac{1}{4}$-inch diameter; 2 foot-bridge cables, each $2\frac{1}{2}$-inch diameter; and several other smaller ropes, but each in its place indispensable to the work. The carrier was taken over in the same way as the first traveller, through the water, and the remaining ropes were mostly drawn across on it. A "buggy," a small swing-stage 4 feet square, ran on the carrier as the boatswain's chair did on the traveler. An oak timber 10 feet long by 6x8 inches was held by stirrup-bolts on the carrier, close to the water-face of the Brooklyn tower, and a large cast-iron grooved sheave hung from this, into and through which the larger temporary cables were hoisted by leading manilla ropes worked by an engine. While a hauling rope from New York pulled the end across, the Brooklyn engine helped haul the rope up from the coil. As the end came over, it was passed through hangers on the carrier. At New York it was secured to an iron anchor in the masonry. The Brooklyn end was meanwhile carried over the tower to the anchorage, and there strained up till the hangers were relieved of its weight, when they were taken off by men in buggies. Over the towers the cables ran on oak wheels six inches thick and three feet diameter. After the hangers were removed, the cables were still further tightened till they reached the right deflection over the middle of the river, then lifted out of the oak wheels, and firmly fastened. The five large cables were laid across in this manner. The others came on the traveler or on the foot-bridge.

THE FOOT-BRIDGE.

This foot-bridge was indispensable in the work of laying cables such as support the Brooklyn Bridge. Its floor was laid on, not under, its special cables, and was made of slats four feet long by 3x1½ inches, laid 2 inches apart, and clamped to the cables by half-inch stirrup-bolts. On either side a ⅝-inch wire rope became a handrail. Thus an unbroken pathway 4 feet wide was laid from anchorage to anchorage, passing over the tops of the towers, and deflecting towards the middle of each of the three spans. The situation was an airy one, and in a breezy neighborhood. The draught came not only over the sides but through the floor, whose cracks were more than half as wide as its boards. This "porousness" gave the wind less hold, and reduced oscillation. Not only was it of daily use to the men at work—Mr. Farrington crossed it fourteen times in one day—but this opportunity for a unique semi-celestial walk attracted multitudes, who asked and got the privilege of going over it from city to city during the many months it hung in air. Seldom did the seeking eye in daylight fail to discern pleasure-passengers traversing its slats, looking in the aërial distance like erect ants. Even there the eye could almost always distinguish the fluttering robes of the gentler sex mingling with the garments of the sterner.

THE CRADLES.

And this suggests the "cradles." These were wooden platforms four feet wide and more than forty feet long, placed in pairs, end to end, and fastened together, so as to make a continuous platform four feet wide and more than eighty feet long, reaching across all the cables, and with substantial oak railings around them. There were five pair of these, one between each anchorage and its tower, and the other three in the main span, placed substantially as quarter, half and three-quarter poles. The foot-bridge passed through one end of each of the five pair, and their flooring, like that of the foot-bridge, was thoroughly "ventilated." These cradles were put together on the ground and hoisted to the tower top by derricks, whence they were slid on the cradle cables to their respective positions and fastened there. This, before the floor of the foot-bridge was laid.

THEIR USES.

The primary use of these cradles was to furnish a place where men might stand and control and regulate the wires as they were run over to form the strands of the prospective cables. They also carried iron sheaves to support the travelers, each of which was supported at seven points, namely, five cradles and two towers in its path either way across the river. So arranged, the transit from anchorage to anchorage became much more steady than, if not as thrilling as, that Mr. Farrington took amid such wide-spread excitement.

THE GREAT CABLES.

And now comes the work to which all these travelers, and carriers, and cradles, and buggies, and foot-bridge are subordinate and preparatory: the formation of the cables. And what is a cable? It seems a simple name, and suggests the connection between a ship and her anchor. But there are cables and cables. Those here to be made, are unique, and uniquely made. Each of the four weighs nearly 900 tons, and is made of 19 separate "strands," each 3578½ feet long. But what is one of these 19 strands?

THE STRANDS.

Each strand contains 278 wires, or rather, to make one strand, a continuous wire runs back and forth from end to end of the strand, the round trip being made 139 times. At each turn at the Brooklyn or the New York anchorage this wire goes round the groove in a "shoe" of cast iron held in the open fingers of the bifurcated anchor-bar, as before described. Thus passing back and forth 278 times the 3578½ feet, the wire is more than a million feet, a little under 200 miles, in length.

THE SHOE.

This "shoe," around which the wire of a strand is made to pass and repass so many times, and which at last holds the end of the strand bolted between the open fingers of the last anchor-bar, is 21 inches long, 17 wide, and 4 thick. There is a slotted opening through its flat to receive the pin, which finally holds it. A casting called a "leg," 11 feet back from the ends of the anchor-bars, holds this shoe while the strand is winding.

THE WIRE.

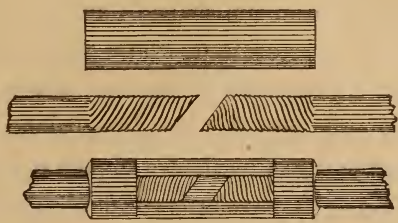
The wire used in the strands is of steel, galvanized, No. 7 size, a little over an eighth of an inch through, and the machinery for making it into cables was set up on the Brooklyn anchorage. Here the wire was delivered. It received one coat of linseed oil and two of boiled oil, mixed with a little powdered rosin and litharge, each thoroughly dried before the next.

"DRUMMING UP."

But the coils of wire must be made into a continuous line, and wound so as to be readily unwound when the strand comes to be made. Wooden drums, 8 feet outside diameter, 16-inch face and flanges to hold 6 inches depth, each with a capacity of about 40,000 feet of wire, were hung in upright wooden frames. There were 32 of these, 8 for each cable. Spoke-handles were used to wind the wire on from the coils, and brakes to regulate the speed when run out. The reels were set behind the drums, and between each drum and reel a man was placed to guide the wire as it passed upon the drum, through a piece of oiled sheepskin held in his hand, thus giving it another coating of linseed oil—the last it was to get in its "individual capacity," that is, as a single wire.

SPLICING.

When the end of the wire in a coil was reached, that and the first end of the wire from another coil were spliced. A right-hand thread was cut on one wire and a left-hand thread on the other, and corresponding threads in a coupling or sleeve, which was then screwed on till the ends overlapped each other. This made the



SPLICING—SLEEVE, WIRE-ENDS, WITH RIGHT AND EEFT THREADS, AND SPLICE COMPLETED.

coils into a continuous wire, and prevented their unscrewing and falling apart, when the unwinding gave them a rotary motion. The joints thus made were galvanized in melted zinc. So the end of the wire from one drum was firmly fastened to the beginning of the wire from the next; and any accidental parting of the wire in any stage of the succeeding processes was prevented.

THE GUIDE-WIRE.

The strands were made at an elevation much higher than the place of the completed cable. The wind here was less liable to disturb than below, and the greater strain on the wire was likely to disclose any imperfection. For this purpose, the shoe around which the wire was to pass was set back the eleven feet from the bolt between the fingers of the anchor-bars, which was finally to pass through it, as before described. The wires of each cable were regulated by a separate wire called the guide-wire. The length of this was first determined while hanging at the deflection the cable would be left at. It was then drawn back an equal distance on each anchorage till it reached the height at which the strands were to be made, and held there till the first few wires of a strand were regulated by it, when it was laid aside till wanted to set another strand by.

THE TRAVELING SHEAVE.

The wires were carried across the river on what was called a "traveling sheave." A light wooden wheel, of 5 feet diameter, with a galvanized sheet-iron rim shaped like a V, turned easily on a spindle attached to a bar of iron, whose upper end was crooked like a "goose-neck." This crooked end was lashed to the traveler-rope, and the lower end carried a cast-iron balance-weight. This goose-neck enabled the traveling sheave to pass over the supporting sheaves which kept up the traveler-rope at the towers and cradles, without slackening speed. The end of a wire from a drum was made fast to the "leg" on the anchorage, the bight put around in the groove of the wheel, and the traveler was set in motion, thus unwinding the wire from the drum. When the traveling sheave carrying the bight of a wire reached the New York anchorage, there were two wires added to a strand, one attached to the "leg," and the other that between the traveling sheave and the drum. The wire unwound two feet in length from the drum for every foot traversed by the traveling sheave. As one traveling sheave went across with its bight of wire, another sheave, lashed to the opposite part of the traveler-rope, returned empty. And when the 278 wires had all been stretched across, the wire was cut, and its end spliced to its beginning, that first fastened to the "leg."

"REGULATING" THE WIRE.

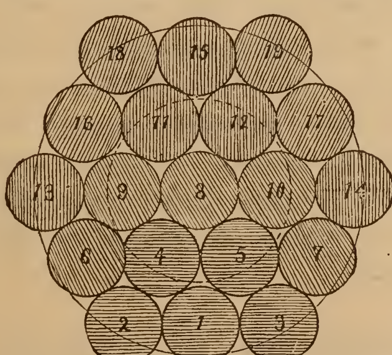
Men had perpetually and carefully to watch every part of the winding. When the traveling sheave passed the first tower, "regulators" there seized it with nippers and a tackle, and hauled in until the regulator in the cradle between the tower and the anchorage signaled that it was in line with the guide-wire. So again the wire was regulated in the main span, and again on the New York land span, the wire having first been placed around the shoe. So back to Brooklyn in reverse order. Care was taken that the two sides of a strand should be kept entirely separate throughout their whole length.

WRAPPING THE STRAND.

This gigantic skein, not of thread but of wire, wound around the shoes at the ends two thirds of a mile apart, as thread around the outstretched human hands, has now to be wrapped to give it unity and make of its 278 single wires one strand, weighing nearly 50 tons. The skein is wrapped, at intervals of 28 inches, with a half-dozen turns of No. 14 galvanized iron wire, to keep its threads in place till the final wrapping of the completed cable. This is done by men in buggies. A most plentiful coating of linseed-oil is also applied.

"LETTING OFF."

Then the strand has to be lowered to its final rest. The shoes, which were put 11 feet back of their place, are turned from the flat position in which they received the turns of the skein to the



SECTION OF CABLE BEFORE THE STRAND FORMATIONS WERE DESTROYED, AND NUMBERED TO SHOW THE ORDER IN WHICH THEY WERE PUT IN PLACE IN THE SADDLES.

perpendicular position in which they are to lie between the fingers of the anchor-bars, and gradually let forward. The iron rollers which support the strand above the saddles are removed, and the strand lowered to its normal place in the saddle. The strands have been made a little long, and they are taken up to the exact length by a cast-iron segment laid between their bight and the anchor-bar pin. At the temporary height the strain on a strand is rated at 75 tons. One third of this strain is taken off by the lowering.

TEMPORARY CENTRAL CABLE.

When twelve strands are thus finished, seven of the central ones are clamped together into a temporary nine-inch cable. The diagram shows the order in which the different strands are laid in the saddles, and how the seven could not be clamped together until the twelve were finished. The first strand lashings are taken off, and new wrappings, 2½ inches wide, are put on at ten inches intervals. The object of this wrapping, as of the previous one, is to assist in bringing the wires more compactly together in the completed cables.

A STRAND BREAKS LOOSE.

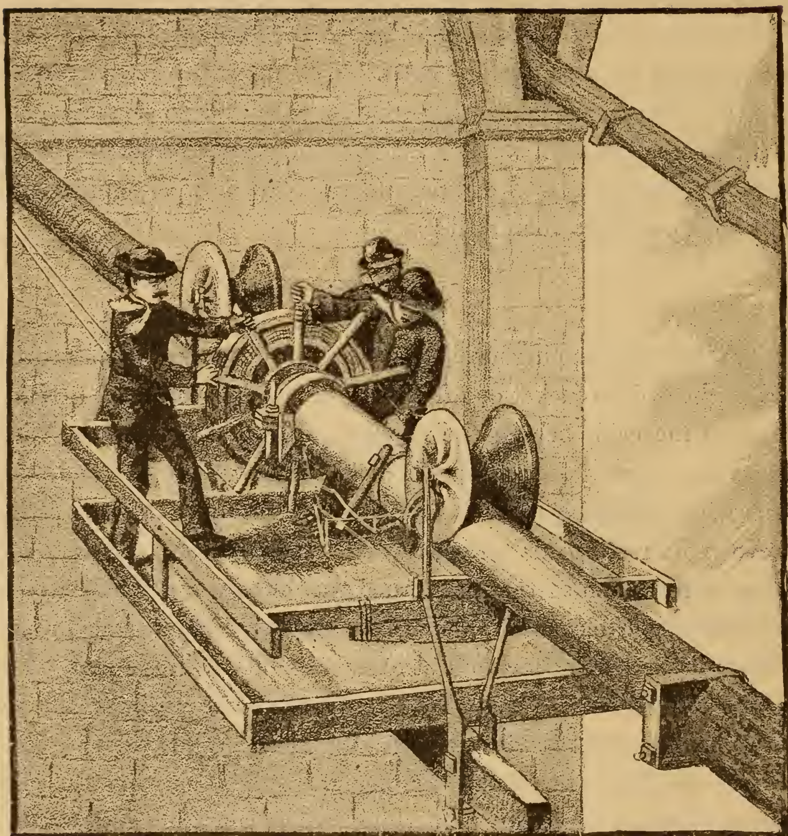
A whole strand was lost by an accident June 14, 1878. A wire rope in the machinery for letting off gave way, and the strand sprang into the river, killing two men and injuring three. Its cause was unknown, as those who might have explained, instantly perished. If the strand had struck across a ferry-boat it would have caused a terrible disaster. But happily the damage was confined to the loss of the men alluded to and of the strand. The strand was cut into lengths of 400 feet, and fished up from the bottom of the river.

DESTROYING THE STRAND FORMATION.

When all the 19 strands of a cable had been formed, regulated, and lowered, the work of clamping and final wrapping began. Wooden clamps were put on the whole length of the cables, 100 feet apart, and wire wrappings between the clamps. The wrapping began at the towers and was carried on each way from them at the same time. A wrapping buggy, 12 by 8 feet, like the smaller ones in all but size, suspended from the cable, held and carried the men and tools for wrapping. The earlier wrappings were cut off for a few feet ahead. The linseed-oil put on when the strands were wrapped helped keep the wires together, and there was no perceptible enlargement of the mass. Next, squeezers were bolted around the cables. They were made in halves to closely fit the cable, and compressed by long vertical bolts. Two men with long wrenches on the squeezer bolts, another sometimes with a small tackle, and much pounding with wooden mallets, completely broke up the old strand formations, and compressed the 5282 now separated wires into one complete round cable.

WRAPPING.

Next the wrapping-machines were put at work. Each consisted of a cast-iron jacket one foot long in two halves bolted together around the cable behind the squeezer, fitting closely on the wires next the towers, but flaring a little toward the other end, that the wires might be more easily gathered into it. On this jacket revolved a reel, furnished with wooden handles, carrying the wrapping wire, which as the reel turned was closely and hardly wound around the cable, the whole machine being forced along the distance of the wire's thickness at every revolution of the reel. The cable-wire received a coat of oil in front of the wrapper, and the wrapper was painted with white lead and oil. When the wire from a reel was gone, that from another was spliced on, and the joint swaged and galvanized. Sometimes, where couplings in the cable-wires were thick, the hands could not force the reel over the spot, and had to be assisted by pulleys and weights. The wrapping of 20 feet a day was good work for a machine, and two machines needed ten men.



WRAPPING THE CABLE.

CABLES FINISHED.

At last the four completed cables hang gracefully in their three loops, passing from anchorage to anchorage over the towers, and ready for the burden allotted them, and to serve as a pathway when needed, for which purpose each cable has a wire-rope handrail on either side. As the shining threads hang high in air, they seem as natural and inevitable as if they had grown there in the usual course, and give no hint of the slow and painful labor that has marked every inch of height from nearly 80 feet under ground to nearly 280 feet above it—a line up and down of more than 350 feet. The passenger over the river can hardly remember that they were not always so, or imagine how the familiar watery highway would appear without them.

HANGING THE ROADWAY.

How shall the roadway be hung from the cables? First, suspender-bands are to be put on the cables: from them by means of sockets are to depend wire ropes holding at their lower end other sockets; these sockets hold the floor-beams; and the floor-beams hold the planking.

SUSPENDER-BANDS AND SOCKETS.

The suspender-bands are of wrought iron, five inches wide and five eighths of an inch thick. They hug the cables, and below terminate in two lugs seven eighths of an inch thick. Men in the buggies with little forges heat the backs of the bands till they can be spread around the cable, keeping a thin plate of iron between the heated part and the cable till it cools, that the galvanizing of the cable may not be disturbed. An iron screwbolt $1\frac{3}{4}$ inch in diameter, put through the lugs and tightened, holds the suspender-sockets. These sockets are made like a fire-bucket with a large bail and a thick bottom. Through this bottom is a hole to receive the suspender-rope, only just large enough at the lower side to receive the rope, but flaring to nearly twice that size at the top. Through this hole is put the end of the rope, its strands and wires are opened and spread apart, round taper pins driven into the interstices, the ends of the wire turned over the pins, and all filled and covered with melted lead, which keeps out water and binds the pins and wires in place.

SUSPENDER-ROPES, SOCKETS AND STIRRUP-RODS.

At the bottom of the suspender-ropes another socket is fastened in the same way, made of cast iron, and with a hole each side of the suspender-rope to receive the stirrup-rods, which hold the floor-beams. These stirrup-rods terminate in long screws, by which the floor-beams can be adjusted to the proper height, as the suspender-wires cannot be cut and fastened with the needed exactitude.

FLOOR-BEAMS.

The steel floor-beams are 85 feet long, made and hung in two parts, and riveted together by plates over the center joints. They are 32 inches deep and 9⅝ inches wide. Each beam has two top and two bottom chords formed of steel channel-bars, tied and braced together in the form of a triangular lattice girder. They are hung 7 feet 6 inches from center to center, and between each pair of principal beams a lighter I-beam is placed, so that the floor-planking is held and fastened every 3 feet 9 inches from centers. Wooden bridging between the beams resists the strain of the over-floor stays.

LAYING THE FLOOR.

The first part of the flooring to be put in place is that through the towers—59 feet in each. This of course is solidly fastened to the masonry. Then, either edge being reached, the nearest suspender-ropes with their stirrups are swung into the tower, and the half section of floor-beam put in, swung out, fastened in place, ready to hold planks from which the workmen may launch and fix the next beams; and so on, each way from each tower. When the other section of floor-beams are out, the two are bolted together.

CABLES BELOW THE ROADWAY.

But the cables enter the inner face of each anchorages below the top; and for 260 feet from the anchorages the floor rests on the top of the cables, being supported on wrought-iron posts resting on cast-iron steps clamped to the cables. And in the main span, the cradles reaching down and the roadway climbing up at the center and for some distance each side, the cable falls below the roadway and supports it in the same manner as near the anchorages. So each way from the towers the cable and the roadway converge, the suspender-ropes are shorter and shorter till "the dog gets ahead of the wolf," and the posts begin and lengthen till the cable again begins to rise.

THE SUSPENDER-STAYS.

But the cables are not the only supporters of the roadway. Fastened to the ends of the iron beams running from face to face through each tower, near its top, another set of suspender ropes or stays diverge, the first reaching to a point in the roadway 15 feet from the tower, the next 15 feet further, and so for 150 feet each way from each tower. These ropes or braces would themselves nearly or quite support the whole roadway, with no help from the cables. They make, with the perpendicular suspender-ropes, an unique appearance—the latter at equal distances and all parallel; the former like the frame of a fan, or the radii of a circle cut off untimely by the suspended roadway.

THE LONGITUDINAL TRUSSES.

From anchorage to anchorage of the great Bridge, stretch in unbroken continuity six lines of steel trusses. Firmly bolted together and to the masonry of the towers and anchorages, they become another element of vast strength to the structure. It is estimated that for an hundred feet each way from the towers these trusses are of themselves strong enough, without help from stays or from cables, to carry all the weight that may come upon them.

PREVENTION OF LATERAL MOVEMENT.

Another ingenious device helps to give great solidity and stiffness to the suspended structure. The two inside cables pass over the central pier very near together, but are drawn out as they descend, till where they pass through and under the flooring they are at the extreme outer edges of the footway on both sides, and the outer cables are correspondingly drawn inward. At three places, each side of each tower, the outer cable and the inner one next it on each side are drawn together, nearer and nearer as they are farther from the towers. This is done by heavy wire ropes; and between the two inner cables the same result is assured by a stiff iron beam or bar, pushing in the same direction as the others pull. The suspender-ropes do not descend plumb down, but are drawn inward, each pair towards their own half of the Bridge. This holds the Bridge with the greatest firmness against lateral pressure.

THE LATERAL BRACES.

From the eyes built in at each corner of the towers, just below the roadway, run heavy floor-braces under the structure, diverging more and more from the tower laterally as the suspender-stays do longitudinally. They are fastened to the side of the roadway opposite that corner of the tower from which they start, and thus present a firm resistance against any tendency of the structure to swing sideways. Beyond the spots where these braces hold at one end on the towers, the diagonal braces are still continued, holding from opposite sides of the Bridge.

UNIVERSAL STANCHNESS.

So that the Bridge is held in its normal place from anchorage to anchorage, by the cables, by the suspender-braces, and by the longitudinal trusses, acting up and down; and braced across by the inward pull of the suspender-ropes, and the lateral braces. And the heavy bolting of the trusses in every direction adds another element to the strength and stanchness which make the structure seem, not a bridge, but a street.

VIEW OF BRIDGE, FROM BROOKLYN, JUST SOUTH OF FULTON FERRY.

THE PATHWAYS ON THE BRIDGE.

THE FOOTWAY.

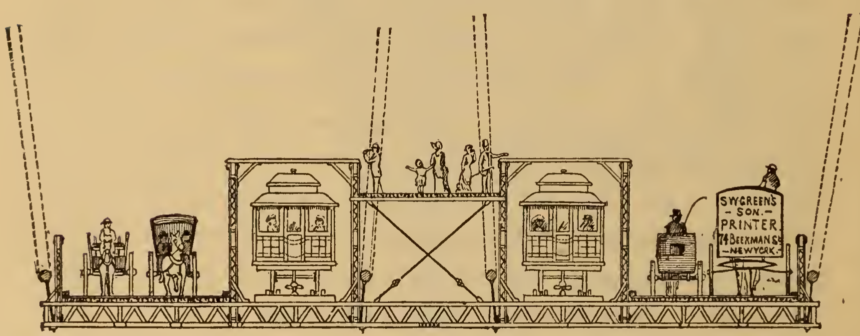
The longitudinal trusses divide the Bridge into five parts or sections, averaging about sixteen feet in width. In the center is the promenade or footwalk, its pathway raised a dozen feet more or less above the flooring of the Bridge, safely railed on either hand. and by its height thus affording the pedestrian a view on both sides which he could not otherwise get. When it reaches either tower, which is a solid pier between its two openings where the promenade would pass in a straight line, it passes by stairs to a railed platform still higher which extends all around the pier, through the openings above the railway ,and down again the other side to its first level. As the promenade approaches either terminus it descends to the level of the roadway proper, so that pedestrians enter it directly from the street and on its level. The promenade on the two approaches is built solid and covered with concrete. On the suspension-bridge proper, that is, on the two land spans and the main span, the floor is of plank, laid lengthwise. The space underneath this promenade is occupied by telegraph-wires.

THE RAILWAY.

Next the promenade, on either side, is a section for the cars run under the Bridge management, from end to end by an endless wire rope. These cars will be commodious, run rapidly and frequently, and be propelled by an engine erected near the Brooklyn terminus. As the grade of the Bridge descends its $3\frac{1}{4}$ feet to 100 toward either terminus, the railway keeps an elevation that brings it out on a level above that of the footway and of the driveway, passengers reaching and leaving it by means of stairs. But the railway future of the Bridge is yet to be developed. Probably the boldest of us would gasp if he could see the traffic which the year 1903 will witness upon it.

THE DRIVEWAY.

The two outside sections of the Bridge, one looking down toward Governor's Island and the harbor, the other toward Williamsburgh and Long Island Sound, are each 18 feet 6 inches wide, and de-



SECTION OF BRIDGE, SHOWING DRIVEWAY, RAILWAY TRACKS, AND FOOTWAY.

voted to vehicles. The inside of the trusses which form the boundaries of this drive are lined with heavy protective metal slips crossed lattice-wise, which, while they make the transit safe, do not obstruct the eye, and offer slight resistance to the wind, which up here is comparatively unbroken. Of course, the driveways, as well as the promenade between them, end and begin on the street-level. On the approaches, the driveways are paved with Guidet blocks, and on the suspension-bridge proper with planking laid crosswise. A few Nicolson blocks of wood set on end are put in as an experiment.

EXPANSION-JOINTS.

Heat and cold have not been ignored in the construction of the Bridge, and the expansion and contraction they irresistibly create have been provided for. In the middle of each land span, two sets across the bridge of the suspension-ropes are hung almost close together. The inner ends of the trusses they carry are arranged to slide out and in with each other, the suspender-ropes carrying all the weight. This allows the spans to expand under heat, and to recede under cold. The planking of the footway runs lengthwise, and its planks stop a few inches short of each other at these joints; and over them and a couple of inches up from them, a narrow plank is fastened across the gap, at right angles to the others. Similar provision is made in the driveway. The openings in this planking through which the suspender-ropes pass from the cables to the floor-beams, are cut into longer and longer ovals as they approach either way the expansion-joints, to allow thus for lengthening and shortening. The railway-track allows for expansion and contraction in the usual way. The same arrangement is repeated midway of the main span, which is here above, not below, the cable.

ELECTRIC LIGHTS.

Along the boundary on either side between the driveway and the railway-track, run rows of United States electric lights, at equal distances, alternately on one side and the other, high enough to light the promenade in the center of the Bridge, as well as its two sides. Over each light is a reflector throwing its rays downward, and protecting it from the weather. From terminus to terminus there are 52 of these. Provision is also made for the escape of surplus water on the approaches.

NEW YORK AND BROOKLYN, AND THEIR ENVIRONS.

GROWTH OF NEW YORK.

New York, the chief commercial city of the United States, contains, and has for many years contained, the largest population of all. Its growth since 1790, when the first Federal census was taken, has been as follows:

Year.	Population.	Rate of increase, p. c.	Year.	Population.	Rate of increase p. c.
1790	33,131	....	1840	312,710	59
1800	60,489	83	1850	515,547	65
1810	96,373	60	1860	813,669	58
1820	123,706	29	1870	942,292	16
1830	197,112	60	1880	1,206,299	28

Over 150,000 of the increase from 1870 to 1880 was due to the annexation of the southern part of Westchester County, incorporated in New York City after the Census of 1870 was taken. The increase from 1850 to 1880 was 690,752, or 134 per cent. This rate would make the population in 1910, 2,822,740.

GROWTH OF BROOKLYN.

Brooklyn (originally named Breuckelen, *Brook-*, or *Marsh-land*, after the ancient village of the same name in Holland, some eighteen miles from Amsterdam) now ranks as the third city in the United States. Its growth since 1790 has been as follows:

Year.	Population.	Rate of increase, p.c.	Year.	Population.	Rate of increase, p. c.
1790	Unknown.	....	1840	36,233	137
1800	3,298	....	1850	96,850	167
1810	4,402	33	1860	266,661	175
1820	7,545	71	1870	396,099	49
1830	15,292	101	1880	566,663	42

Part of the increase in the decade preceding 1860 was due to the incorporation into Brooklyn of the present "Eastern District," which before was Williamsburgh, etc. The increase of the city from 1850 to 1880 was 469,813, or 485 per cent. This rate of increase would make the population in 1910, 3,314,978. Long before that time the two cities will be united, and, following the ratio of the last thirty years, with a population of 6,137,718 souls (if, as Charles Lamb said, you count a soul for every body).

THE TONGUE ON WHICH NEW YORK STANDS.

Manhattan Island, on which New York City proper is built, is a long and narrow tongue of land surrounded on three sides by the Hudson River and the Atlantic Ocean, and on the north by Harlem River and Spuyten Duyvil Creek. This tongue contains about 22 square miles, or 14,000 acres, and is 13½ miles long with an average width of less than two miles. The up-and-down horse-car lines and the different elevated railroads carry an enormous number of passengers daily. On the Third Avenue Elevated road, trains of four cars, all heavily loaded, follow each other too closely for safety during the hours of greatest travel, and even then would-be passengers have to wait train after train to get on. The elevated roads seem to have provided merely for the normal growth of travel, leaving the old surface roads still overflowing with business.

MANY NEW YORKERS MUST LIVE OUTSIDE THE CITY.

Of course, as New York grows in numbers, a constantly increasing population of those who do business there must "live" away from its present limits. The roads running north into Westchester County accommodate multitudes, many of whom find homes even farther north than Westchester, and northeast clear into Connecticut. These cross tide-water on drawbridges over the Harlem River and Spuyten Duyvil Creek, from seven to fourteen miles north of the City Hall. Other multitudes live in places accessible by steamboats, which run in various directions, enabling many to live at a distance of 30 and more miles from the City Hall in New York.

NEW JERSEY.

But the great mass of those who do business in and reside away from New York go and come by the various ferries. The Hudson, on the west side of Manhattan Island, separating it from the Jersey shore, is a magnificent river, here about a mile and a half wide. Across it many ferries ply, carrying passengers who live within walking or horse-car distance of home, and other passengers to whom the ferry is only one end of a railroad journey. From different points on the Jersey shore these railroads radiate like fan-sticks, from the roads leading through Long Branch and Ocean Grove, due south from New York, away around to the New York, West Shore and Buffalo, running a little east of north, and hugging the Jersey shore under the Palisades. Passengers on several of these railroads go west from the river through tunnels, cut for more than a mile under the hill. Each working day there go and come from the Jersey ferries almost 900 separate trains, on nearly 40 separate lines of road. To and from Newark there run 300 trains daily, on five different roads. But the long ferry journey must be taken twice a day by each passenger between New York and the station where the locomotive takes or leaves him. To abridge this delay and simplify the journey a tunnel is now being built under the Hudson—an enterprise ranking in importance and in difficulty with the New York and Brooklyn Bridge.

STATEN ISLAND.

Southwest from New York lies Staten Island, its nearest or northwest corner about six miles from the city, the route being over New York Bay. One line of ferry-boats connect New York with the "North Shore," and another with the "South," really the west ho re. Their boats land a very few miles one way or the other from the northwest point of the island, leaving residents a horse or steam ride to get to or from home. The island is about 13 miles long, and contains 58½ square miles, or more than twice and a half the area of Manhattan Island. The census of 1870 gave it a population of 33,029; that of 1880, of 38,991. Manifestly, under present conditions, the overflow of New York is not going to seek Staten Island.

LONG ISLAND AHOY!

To the eastward of New York City stretches out 100 miles, to a point opposite Stonington, Conn., LONG ISLAND, with an extreme length of 115 miles, an extreme breadth of 23 miles. and an area of 1682 square miles. Its western end extends for 8 or 9 miles opposite New York and as many more south of it. Against its southern and eastern line rolls the Atlantic Ocean, against its northern Long Island Sound, and its western end is watered by New York Bay and the narrow strait which connects the Bay and the Sound, here misnamed the East River, a strait for considerable distances only a little more than half a mile wide. Opposite the most densely populated part of New York lies Brooklyn. As over the Hudson River, so over the East River multitudes of ferries ply. With the exception of a few short roads running to different Coney Island beaches and to Rockaway, the railroad service on the island belongs to one company—the Long Island. The growth of Brooklyn shown in the preceding table indicates what multitudes have found their homes near the water within its limits. Which way the tide of new residences most strongly sets, to Long Island or to New Jersey, the census partially tells. New Jersey, in the path of all southern and a great deal of western travel, crossed in every direction by multitudinous lines of railroad on its 8320 square miles of territory, increased from 906,096 in 1870 to 1,131,116 in 1880—a gain of only 225,020, or about 25 p. c. Long Island, with less than 400 miles of railroad on its 1680 square miles, all belonging, with the exception of the Coney Island roads, to one lone company, is not on any "through" route, and her travel is altogether her own. Yet she increased from 544,190 in 1870 to 743,957 in 1880—a gain of 199,767, or more than 36 p. c.; the gain of Kings County, which lies opposite New York, being nearly 43 p. c. in the ten years.

THE TRAVEL OVER THE OLD BROOKLYN FERRIES.

The ferries which connect New York and old Brooklyn, or the territory bearing that name before the incorporation with it of the Eastern District, all belong to one management—that of the Union Ferry Company. These ferries are five in number, and transported during the 12 years ending April 30, 1883, 532,198,514 passengers, an average for the 12 years of 44,349,876—well towards a million per week. The increase has been, years ending April 30:

	1871.	1883.	Increase.	Rate.
Catherine Ferry	5,180,421	6,980,272	1,799,851	35 p. c.
Fulton "	20,573,797	22,127,953	1,554,156	7 p. c.
Hamilton "	6,003,901	9,886,769	3,882,868	64 p. c.
South "	4,587,839	7,123,368	2,535,529	55 p. c.
Wall St. "	4,982,635	5,246,524	263,889	5 p. c.
	41,328,593	51,364,886	10,036,293	23 p. c.

FERRIAGE DIFFICULTIES.

It goes without saying, that the transportation of the vast mass of humanity and freight over the various ferries across the East River, like true love, does not always run smooth. The morning travel to New York is spread over much more time than the return tide. In the neighborhood of 6 P.M. the pressure is enormous. If the elements and the passengers were always on their good behavior, the problem would not be nearly as hard as it actually is. The narrowness of the strait through which Atlantic tides must ebb and flow twice a day makes their current strong and variable.

Only a little while four times a day is the tide willing a boat should take a straight course anywhere across its current. At other times the boats are swept up or down as that current flows or ebbs, and only skilful pilotage can bring them in. The wind, too, conspires with the tide to upset calculations. Nor is the "river" itself a clear course for the ferry-boats. It is full of craft, propelled by oar, by sail, by steam, or towed. Here comes a great ship going to dry-dock, a small steamer each side, and another ahead. Here is a large tug with three schooners made fast each side, slowly working towards Hell-gate; and here are fishing-smacks under sail beating down to market, and needing the whole stream to themselves. Here comes the "Maryland," the boat by which Gen. Butler circumvented and conquered Baltimore in 1861, now carrying three rows of loaded cars on the through Washington line that evades New York. The whistle of the "Bristol" or the "Providence" booms out once or twice to tell you whether she is going to right or to left, and to give you fair warning to clear the track. On comes the monster, paying as much attention to you as a loaded six-horse stage in the White Mountains coming down a long hill in the woods pays to the one-horse buggy or buck-board, from which he and she descry the towering mass approach. Then comes a large tow behind an insufficient steamer with 150 feet of line. Here are three boats filled with refuse, 100 feet apart, slowly dragged down the Bay, to worse than waste fertilizing matter that ought to issue in greater produce from gardens, orchards, and granaries. Here go a couple of excursion barges packed with a Sunday-school or other pic-nic, towed by one steamer and each trailing a row-boat carrying a man. Here comes a little steam yacht, and there a great one under sail. And here comes a huge spar, slowly towed by a man or men in a row-boat. Last week a vessel was stove and sunk there in the channel. At low-water you can see the top of her mast. At all times of tide keep away from her. That dredging scow is anchored, and will not swing against you unless the tide is turning. But keep away.

THE FOG.

But more annoying and more dangerous still are the fog and the ice. A dense fog shuts off the view of the opposite end of the boat perhaps, and the other side of the river is as invisible in broad daylight as the good time coming was to the Lancashire weaver. All steering must be by the sound of bells; and each ferry dares have only a single boat out at once. No teams allowed, and their places, as well as the cabins, are occupied with a mass of humanity packed so dense that its units can hardly move. The other boat having come into the other slip, your pilot creeps out, steering by the regular beats of the particular bell he knows is for him. As at last he slowly enters the slip, the other boat goes out, and so on.

THE ICE.

Then, again, in the winter great fields of ice form in the inlets and bays, are lifted out by the tide, and go floating up and down the stream, moving with the ebb and flow. Occasionally the cold fixes them, and an ice block ensues. Ferry-boats having to go back and forth without turning cannot use screws, but must move by paddles, around which the ice gathers, and which pound the ice-blocks as they revolve. At intervals of years the strait has been entirely frozen over, so that during a part of one tide people could cross. These delays and exposures, so vexatious and dangerous to man and beast, deter many a family which would otherwise gladly live in Brooklyn. Crowded boats have been on the water more hours between New York and Brooklyn than an express train takes between New York and Boston. It speaks wonderfully for the management of the Brooklyn ferries that no great accident has ever happened to these crowded boats; but the danger is always imminent and the discomfort ever present when fog or ice are to be encountered. Pleasant as the passage of the river generally is, there are most undeniable drawbacks from which ferry-boat transit cannot be liberated.

THE RELEASE.

But now, over the water stands the solid Bridge, offering an uninterrupted pathway for man and beast, which no fog or ice, no bewildering currents, no snarl of boats, no river or ocean leviathan, can interfere with. While the eye scans the crowded water-way beneath, the elements, before so disturbing, take their places as part of the great moving panorama spread only for our delight. As the guest, safely housed in the warm and lighted parlor, sees and enjoys through its windows the driving storm from which he has just emerged, so the passenger over the Bridge views the commotion, a part of which he was, but no longer is. Is that the "Pilgrim" steaming along in a direct line with the spot where you stand? Let her come; and from your serene height look down upon her deck—even into her smoke-stacks, if you like—as she passes harmless beneath.

THE NEW THOROUGHFARE.

To look up at the Bridge from below, the first impression is that its 135 feet above high-water is a dizzy elevation to climb. The descent on either side to the level of the ferry, and the climb again on the other side, are somehow ignored. But the pedestrian, as he goes from Washington and Sands Street to Fulton Ferry, has to walk down a descent which would be more than 38 feet in a straight line, and on the other to climb an ascent to City Hall Park of more than 60 feet. The excess of ascent and descent in crossing the Bridge, over the descent and ascent in crossing the ferry, calculating by a right line from terminus to terminus, is more than counterbalanced by the regular grade of the Bridge, which evenly spreads over the whole length the irregularities of the ferry route. One hardly notices whether he is on the up or the down grade of 3 feet 4 inches in 100. The strain on horse-flesh in the transit over the Bridge is trifling compared with the ferry, even leaving out of account the evener paving of the former.

SEEMS LIKE A STREET.

Airy and graceful as the structure seems from below, majesty and strength, crowned by beauty, fill with awe on a closer acquaintance. Can this be a bridge; and can the Atlantic be throbbing underneath? Why, the tread seems as firm as on Broadway; the feet of men and horses in throngs, and the roll of the railway cars, make the same hum and roar you are accustomed to on land, and the tremble is only that you feel when a heavy truck passes your door. The Bridge is actually wider than Broadway.

THE VIEW FROM IT.

But much as there is in the structure to call and hold attention, the eye is constantly tempted away by the scene to which it admits you. All around the horizon New York and Brooklyn lie spread, separated by the water-ways. The mind is busy reproducing the scene that would have met the eye of Hendrik Hudson if he could have been suspended in mid-air at the spot where you now stand. The East and Hudson Rivers showed in glimpses amidst the mighty unbroken forests that reached everywhere to the water's edge. No sound or sight of human occupation could have met his senses. Fish, flesh, and fowl only inhabited these square miles of territory over which the eye to-day roves, fatigued with the endless variety beneath it. On every hand, houses, factories, hotels, churches, lift their roofs and spires, and the hum of the busiest human life is in the air. The waters which Hendrik found unvexed by aught beyond an Indian's paddle, echoing only to the notes of water-birds, are now traversed by innumerable craft, and the air filled by the noise of uncounted steamers. The eye and the imagination find here materials for boundless observation and endless reflection.

THE HUMAN BRAIN.

But whether the eye sweeps the prospect, or is occupied with the great Bridge itself, how the attention is attracted to the achievements of the human brain! Ignoring for the moment all around, consider that this mass of masonry and metal is the product of that matter, of which each one of us carries more or less behind his eyes; that it was called into existence, and set its task by mere vibrations in that porous mass easily lost in the inside of a tall hat; that everything here was first a thought, and a thought only. Where has this Bridge been actually built? In the brains of the two Roeblings, father and son. The younger helped the elder from the start, and, after his untimely death, planned and finished the work. Think of the partially paralyzed body, which in pain and weariness, working by snatches, for long years unable to visit the object of its labors, has held the undimmed mind. "Ah!" said the auntie who first saw a train of cars, "God's works are great, but man's are greater." Surely, the same life beats in both, and there seems no limit of achievement which the human brain, renewed and vivified at each throb with the exhaustless life of the universe, need fear. It sees the statue in the marble, and cuts away from it the superfluous stone. From bristles and canvas and pigments it creates "The Last Judgment;" and a brain more than eighty years at constant work calls into being "St. Peter's at Rome,"and there St. Peter's stands. Printing presses, locomotives, Jacquard looms, steamships and telegraphs, all emerge from its gray cells. And under the incitement of Mr. Kingsley, the brains of the Roeblings took up this mighty task, and here today stands the completed Bridge.

"BAD FOR THE COO."

Now and then a ship or man-of-war has spars so tall that they cannot pass under the Bridge, at its height of 135 feet. In such cases part of the rigging must be taken down if the vessel is to pass. Many a time it seemed from below as if a mast must strike the growing Bridge, but it seldom did, and a timid mind sometimes fears the damage a mast reaching too high up may do the Bridge. Among the objections made to the earliest locomotive was one arising from the fear of the damage a straying cow might work. What would happen if a cow should run into the "moving machine"? "Ah!" said George Stephenson, "it would be bad for the coo."

THE QUESTION OF TOLLS.

THERE has been a great deal of discussion as to whether the Bridge should be free, or whether tolls should be exacted from those using it. It has been urged, on the one hand, that as the Bridge has been built by the cities, its cost paid by mortgaging their property, and as a great public necessity, it is absurd to charge a toll to the residents of the two cities for the use of their own. And it has been further urged that the freer and more serviceable the Bridge can be made, the larger will be the multitude of those who will make Brooklyn their home, and the faster will property increase in taxable value. And to the increase in the value of property the City of Brooklyn should look to reimburse itself for the cost. On the other hand, it is said that it is unfair to throw upon the whole community the cost of a convenience used only by a part; that the plan all along has been to charge toll, and that the trustees, under the law as it is, have no option, but must collect tolls. An act was before the last Legislature, just before its adjournment, to repeal what was by some regarded as mandatory before; but the act did not become a law. In these circumstances the trustees consulted their own counsel, and the corporation counsels respectively of the two cities; and these all agreed that, under the law as it stands, tolls must be charged. At their meeting May 14, the trustees adopted the following schedule of tolls:

Foot-passengers	1 cent.
Car fare	5 cents.
One horse, or horse and man	5 cents.
One horse and vehicle	10 cents.
Two horses and vehicle, loaded or unloaded	20 cents.
Each horse beyond two attached to any vehicle	5 cents.
Neat cattle, each	5 cents.
Sheep and hogs, each	2 cents.

These were adopted provisionally and temporarily, with the distinct understanding that they are to be reconsidered as soon as a sufficient body of experience shall have grown together to give data for more careful calculation. And there is a very general expectation that the next Legislature will destroy all legal barriers to making the Bridge free.

FOOT-PASSENGERS.

The Bridge, complete as it stands in itself, cannot enter on any enlarged sphere of usefulness, until connections are made with it at either end, and it thus becomes the integral part it should be, of the system of travel. To-day, the foot-passenger is landed in Brooklyn at the intersection of two streets, in each of which runs a horse railroad, having its starting-point at Fulton Ferry. To be sure, the City Railroad Company is busy preparing for a depot at the Bridge terminus, where passengers may take any one of their lines. But other cars of all these lines will start from the ferry. Supposing an equal number of passengers who walk to their homes to be accommodated either way. The passenger who is going to ride home is equally accommodated at the ferry and the bridge. During commission hours the fare on the ferry for a ride over on the boat is one cent, the same as for the walk over the Bridge. And for the remainder of the day the ferriage, when tickets are bought, is 17 crossings for 25 cents. Clearly, there is small inducement here for persons who do not start from the neighborhood of the City Hall, to forsake the ferry. If the travel on the ferry-boats is thinned out, so as to leave less crowded accommodation for crossers during the busy hours, that is as much as can be expected.

THE FOOTWAY WILL NOT BE LONESOME.

But thousands on thousands will cross the Bridge because it is the Bridge, and for the sake of the magnificent view it affords. Other thousands of visitors will cross and recross, not to get anywhere, but for the sake of the journey. And as the time to be spent in the transit is not limited, the pleasures it affords will be drawn out, and the average pedestrian will spend threefold, four-fold more time in walking across than he did in riding. There will be a great stream of travel at one cent, and the floor of the Bridge will not be lonesome. And in fog or ice—if the toll system lasts till ice-time comes again—the ferry-boats will run nearly or quite empty.

THE RAILWAY SERVICE.

So as to the railway service. At either end, the cars are up-stairs, and do not now connect with anything. In New York, the City Hall station of the Third Avenue Railroad is close by, and the change made by merely going down one flight of stairs and up another. In Brooklyn, not even that. This will not prevent an immense travel back and forth on the cars. The little Manhattan Beach Marine Railway, Coney Island, carried last season 879,327 passengers, with net earnings of more than $16,500. And the season there is about four months. Is it too much to expect that the average travel over the Bridge Railway will be much greater than over the Marine, and that it will last uninterruptedly the year round?

TOLLS ON THE DRIVEWAY.

The tolls for teams and vehicles over the Bridge adopted by the trustees do not differ materially from those already charged at the ferry. The drivers of freight wagons and trucks will go across the river in one way or the other, according to circumstances. Coming in from Broadway, above City Hall, the passage over the Bridge with its gentle ascent and descent, will be much easier than the more abrupt descent and ascent over the ferry route. Teams from the Post-office and below will probably keep to the ferry—always excepting fogs and ice, when often the ferries refuse all teams for hours. But all the carriages and pleasure travel will take the Bridge, and will be greatly reinforced by those who go to see the Bridge itself. And then one has a point of view from the driveway different from that he has on the footway. In the latter he is high over the Bridge in its centre, but on either side he is more than 30 feet away from its outside railing. On the railway he is nearer one side, but cannot linger at all to take it in. In the driveway he may go close to the lattice that guards interstices of the longitudinal truss, and get a much clearer view on one side only, and can better examine and appreciate the complicated and elaborate truss system, which is mostly hidden under foot from the pedestrian.

THE UNION FERRY COMPANY.

It is not to be expected that the Union Ferry Company, which carries its nearly a million passengers a week, will fold its arms, and allow any paying business it can retain to slip from its grasp. There may be yet hidden capabilities in ferry transportation. A Yankee occasionally asks why a Fulton ferry-boat may not be a two-decker like the Long Island Railroad boats, and take and land passengers from two levels. And the rates of toll for man and beast may be as plastic on the ferry as on the Bridge. There may be no descendant of the Medes and Persians dominant in either direction. And in this rivalry between the two methods, "the forgotten man," as Prof. Sumner calls him,—the man who pays his own way and attends to his own business,—may find his account. Rumor has it that the Union Ferry Company has sometimes hard work to dispose of its earnings, so as not to pay over anything to the city. If this be not false rumor, there may be here an opportunity to serve the public with a better and more economical transfer from shore to shore than it has ever had. The "forgotten man" is quite willing to see it tried, even if the ferry stock should drop a few points in the "market," where, however, it seldom or never comes. And whatever the rivalry, if any there should be, between the two routes, the public cannot but be the gainer.

THE PROSPECT FOR BROOKLYN.

A FEW years ago Brooklyn was regarded only as "a dormitory of New York." But lately the state of things thus described has been rapidly changing. Manufactories have sprung up on every hand, and the steam whistle, the hum of machinery, long lines of operatives, male and female, and trucks and cars loaded with her produce, are met with on every side. The most prominent building in Brooklyn, seen from the bridge, is a factory—the printing-office of A. S. Barnes & Co.—a six-story building filled by a business that three years ago they carried on in New York. And perpetually the resident, passing through some street the first time for two or three years, is surprised at the new factories he then sees for the first time.

RAPID TRANSIT IN BROOKLYN.

The present condition of travel is temporary and tentative only. Rapid transit in Brooklyn is a thing of the immediate future. It has a surface line running from Atlantic and Flatbush Avenue to East New York. To get to it from anywhere down-town one must walk or take the horse-cars. From anywhere in old Brooklyn, the traveller must go to the Long Island Railroad depot to take steam. Spasmodic efforts have been made, dog-in-the-manger enterprises undertaken ; but the outcome so far is, street after street defaced and obstructed by useless unfinished frames and foundations, and no cars running. This state of things cannot last, and in one way or another connection is sure and certain to be made between the ferry and the Bridge, and the Long Island Railroad depot ; and probably not much later to other and more distant points in the city.

Proposed Extension of Flatbush Avenue, from the Bridge to the Depot of the Long Island Railroad.

THE FLATBUSH AVENUE EXTENSION.

A straight line from the Brooklyn terminus of the Bridge to the Flatbush Avenue depot runs diagonally through blocks the whole distance, as the map will illustrate. The bill introduced into the last Legislature by Mayor Low provided for the opening of a wide avenue on that line, without expense to the city, and buying the equities of the property-holders. That bill failed. The probability is that either by public or by private enterprise the connection will be made. If nothing more, the Long Island Railroad Company will extend its system of travel to the Bridge. For that alone there will not be wanted more than half the width a public street would require. There will be undoubtedly enterprise and public spirit enough to cut through the needed avenue wide and ample, with room for traffic, pedestrians, wheels and cars. Beyond the Long Island depot, Flatbush Avenue already extends in a straight line to the entrance of Prospect Park, and beyond that to Flatbush, Flatlands, and the sea.

FUTURE OF LONG ISLAND.

Who can forecast the future of Long Island, of "fish-shaped Paumanok," as a great poet so fitly names it? How it stretches off, one hundred miles long of it, to the Eastward, almost every inch of its mainland easily fit for human habitations: and its sandy beaches none too many for the use of the population it is destined to hold. Across its acres blow salt-water breezes from North, East and South; and even the West has ample water border. And its generally level conformation offers an easy transportation to the increasing multitudes who must do business in the western end of the consolidated city — the present New York. If a country-bred, mountain-loving spirit yearns for a home in an undulating country, where he may see hills and vales, a few miles' ride on the Sound side of the island gives it. Spite of the obstacles of ferry crossing and a long horse-car ride to reach steam, or a half hour water ride to meet steam at the docks, the island, and especially the western end, has grown, and is even now growing, as we have already shown, greatly in advance of any other land abutting on New York waters. Not only has the permanent population of the island so greatly increased, but the late development of its beaches has been even more marvelous. Manhattan, Brighton and Long Beach hotels shelter in the summer human souls enough themselves to people a great city. And the improved means of transit to them afforded by the Bridge when the iron horse shall run to and from its termini, will soon dwarf the proportions of even the large present travel. Even now, hundreds of miles away, the summer traveler sees announcements of excursions made up for Manhattan and other beaches; and the tide has hardly fairly begun to set. The new New York, extending from the Hudson River far along the island, shall draw all the year around, from outside its own borders, a travel, whose proportions can only be guessed.

THE LONG ISLAND RAILROAD.

For, although there is but one management of the railroads which run along the fish's backbone, with their many spurs, that management is a far-sighted, enterprising and wealthy one. The ancient niggardly management which drove the old company into bankruptcy, and its lines into the hands of a receiver in 1877, is a thing of the past. The leading spirit of the present company became then the receiver of the defunct one, and so managed the property that in 1881 the receiver was discharged and the present management came into possession. Now the rails of the road are entirely of steel, and its engines and passenger cars the present summer are unsurpassed. From two and a quarter million passengers carried in 1872, the number rose to nearly nine millions in 1882. The same enterprising management has projected a line of steamers from the nearest land in Wales, Milford Haven, to Fort Pond Bay, just around the end of the northern fork of the island. At Fort Pond Bay, incoming ocean passengers will take the cars of this road, and in two hours thereafter be rolling over the Great Bridge, if their destination is that way. The steady aim of this Company is to improve the track and the stock, to encourage residence and travel in all ways, and to pursue a policy that shall build up the island: the prosperity of the island helping the road, and similarly the prosperity of the road helping the island. Transportation, safe, swift and pleasant, is afforded to those who travel much, as low as half a cent a mile.

THE BRIDGE IN THE RAILROAD CIRCUIT.

When the Bridge shall be taken into the railroad circuit, and passengers transported over it to distant points without change of cars, the great benefits involved in it will begin really to accrue, and united New York will take a fresh start. Men can do business on Manhattan Island, enter the cars at City Hall, and in a half-hour be landed near a home in the country or the village. Boston has long had the reputation of being the city offering unrivaled facilities for getting away from itself, and New York has stayed at the foot of the class. The Bridge puts her at a step, or will put her when the present plans are set in operation, at or near the head. She will become more and more, "beautiful for situation, the joy of the whole earth."

HONOR TO WHOM HONOR IS DUE.

But for all the conveniences and facilities the Bridge affords and is to afford, in the midst of wonder and delight, the music of bands, the noise of cannon, the orator's periods, the blaze of gas and electric lights, and the explosion of fireworks, let us not forget the man to whose "audacious genius" the result is due. Human brains were plenty, there was experience in bridge-building on a smaller scale, there was the need of the structure, and means were on every hand. So in the block of marble the statue is concealed. But William C. Kingsley saw what was not taken in by other eyes, and as the old hymn has it, "he wan to the fruition, Of that which he had seen in vision." With his keen eye on the result that to-day is astonishing the country, through evil report and through good, his long fingers have beckoned the men and have conjured the means, and perpetually pushing here and combining there, always driving in the refractory elements and subordinating them to the great end, the twenty year long labor stands achieved. Over Christopher Wren's grave in St. Paul's, London, is inscribed, *Si monumentum quæris, circumspice: If you seek his epitaph, look about you.* The man who rejoices in the welfare of his race, and who knows that its progress comes mainly from those who have rendered material services, have created the art of printing, called into being the steam-engine, the telegraph, the sewing and the mowing machine, and lifted the daily life of all to a higher level; that their services overtop and dwarf theirs who give themselves to art and to so-called "morals," great as their contributions may be; such a man will regard the Brooklyn Bridge as a monument of which its author may be prouder than if he had written Beethoven's Fifth Symphony, painted the Last Judgment, lived a Confucius or a Mahomet, or built St. Paul's or St. Peter's. Mr. Kingsley happily does not need a monument: but his work stands proudly up and speaks for him; and will long after he shall have passed away.

Of the two leading coadjutors with Mr. Kingsley in this great work, James S. T. Stranahan, still hale and hearty, presides at the opening. The face of the other will be greatly missed; and multitudes will regret that Henry C. Murphy did not live to see the consummation of the work which had employed his busy brain and active hand so many years.

SKETCHES OF MEN PROMINENT IN THE BRIDGE ENTERPRISE.

JOHN A. ROEBLING.
FROM PORTRAIT IN HARPER'S MAGAZINE.

JOHN A. ROEBLING.

John A. Roebling, the great engineer by whose genius the Bridge was designed, was born June 12th, 1806, in the city of Muhlhausen, Prussia. His early education was obtained in his native city, but he received his professional training at the Royal Polytechnic School at Berlin. At that institution he won high distinction in his studies, and received the degree of civil engineer. For several years immediately following this he was employed as superintendent on some government works in Westphalia. He emigrated to this country when about twenty-five years of age, and at first devoted himself to farming near Pittsburg. That period was an era of great industrial and commercial activity, and canals and other public improvements were in process of construction in all the States.

Mr. Roebling, who was soon weary of a farmer's life, again turned his attention to his profession. At first his services were employed in canal work; but railways soon asserted their superiority as a means of transportation and communication, and the energy and activity which had been employed in constructing water-ways were diverted to the building of railways. Mr. Roebling was soon employed by the State of Pennsylvania, then projecting various railways, in surveying and locating lines through the Alleghany Mountains, from Harrisburg to Pittsburg. One of the routes thus surveyed was afterwards opened, and is now the Pennsylvania Railway.

Mr. Roebling next devoted his energies to the manufacture of wire rope, and was the first to produce that article in this country. These ropes were used on the inclined planes of the portage railroad over which the canal-boats of the Pennsylvania Canal were transported. He now undertook the building of a suspension aqueduct across the Alleghany River at Pittsburg, a work which was completed in 1845, and the success of which was so marked that he was selected to build the Monongahela suspension-bridge connecting Pittsburg with Sligo.

In the year 1848 he began a series of suspension aqueducts on the line of the Delaware and Hudson Canal, designed to connect the anthracite coal regions of Pennsylvania with the tide-waters of the Hudson River, the building of which consumed two years. These works are permanent, requiring merely an occasional renewal of the wooden ducts which decay from the action of the water. Not long after these aqueducts were finished Mr. Roebling moved to Trenton, N. J.

He now began the construction of a series of great suspension-bridges which are among the most famous engineering structures in the world, and are surpassed in magnitude only by the New York and Brooklyn Bridge. The first of these, begun in 1851, is the bridge across the Niagara, connecting the New York Central Railroad with the Great Western Railway of Canada, the building of which occupied four years. The span of this bridge, the supports of which are four 10-inch cables, is 825 feet, and it was the first suspension-bridge capable of sustaining the great weight of railroad trains. Even while this bridge was building, Mr. Roebling was engaged on another of still greater magnitude, intended to cross the Kentucky on the line of the Cincinnati and Chattanooga Railroad, with a span of 1224 feet. This work, however, was discontinued on account of the insolvency of the company. In the fall of 1856 the great Cincinnati bridge was commenced. The building of this bridge, the span of which is 1030 feet, was also interrupted by the financial embarrassments of the company, but was at length finished in 1867. During the same period Mr. Roebling built another suspension-bridge at Pittsburg.

In May, 1867, Mr. Roebling was appointed engineer of the New York and Brooklyn Bridge, and in the following September he made his report of surveys, plans, and estimates. In July, 1869, he was badly injured at the Fulton Ferry slip while engaged in fixing the location of the Brooklyn tower, his foot being crushed by timbers displaced by a ferry-boat which was entering the slip. This injury resulted in lock-jaw, from which he died July 22d, 1869.

COL. WASHINGTON A. ROEBLING.

Citizens of New York and Brooklyn may well congratulate themselves that when the untimely death of Jno. A. Roebling deprived the Bridge of its engineer, a successor was found in his son, Washington A. Roebling, who not only inherited his father's talents and genius for great engineering enterprises, but had been closely associated with him in some of his famous undertakings, and indeed had taken no inconsiderable part in the preparation of the plans for the Brooklyn Bridge itself. The father had entertained a high opinion of his son's capacity, and accorded to him much of the credit due for some of the great works with which his own name was associated, particularly the Cincinnati bridge. In fact he remarked, "If I hadn't him, I would not, at my time of life, have undertaken the East River Bridge. If anything happens to me he can push on about as well as I can."

Washington A. Roebling was born in Saxonburg, Pa., May 26, 1837. Until he was sixteen years of age he was educated at the Academy at Trenton, New Jersey, and thence went to the Rensselaer Polytechnic School at Troy. Graduating from that institution in 1857, he at once became associated with his father in bridge building, and at the outbreak of the rebellion was busily engaged on the Alleghany Bridge at Pittsburg. He enlisted in the Fourth New York Artillery as a private, and being sent to join the Army of the Potomac, was assigned to an important post in the Engineer Corps, a branch of the service for which his thorough knowledge of topographical engineering peculiarly fitted him. While in the army he built a suspension-bridge at Harper's Ferry for the use of the troops. He saw much hard service. He was frequently sent

COL. WASHINGTON A. ROEBLING.

FROM PORTRAIT IN HARPER'S MAGAZINE.

out in charge of reconnoitring parties, securing information which proved of value to the army, and part of the time was on the staff of Gen. G. K. Warren. He was present at Gettysburg, and it was for gallantry in that action that he received his commission as colonel. At Petersburg also his services were valuable, at which place he took an important share in the destruction of the Weldon Canal, an act which was effective in cutting off the enemy's base of supplies.

Leaving the army in February, 1865, and resuming work in his profession as an engineer, he was employed on the suspension-bridge at Cincinnati, on which his father was then engaged, and devoted himself to that great structure until its completion. Col. Roebling then visited Europe, where he remained about six months, and made a most careful and thorough study of all the important engineering works in England and on the Continent, giving special attention to the latest scientific information on the subject of pneumatic foundations. On his return he assisted his father in maturing the plans for the East River Bridge. He was thus employed until the elder Roebling's death in July, 1869, when he was promptly appointed his successor as Chief Engineer. While in the caisson directing the work for the Bridge foundations, Col. Roebling's system received a severe shock, which has occasioned him much suffering ever since. While that work was going on his unremitting attention both day and night was required, as the slightest error or want of caution would have imperilled the lives of hundreds of workmen, besides destroying the results of much laborious effort. On one occasion, in December 1870, he was brought up out of the New York caisson in an almost insensible condition, and all the following night his life was despaired of; but he rallied in a few days and resumed work in the caisson, against the protests of his physicians. In spite of his sufferings he has devoted himself unceasingly to the great enterprise committed to his charge, and, released from the heavy strain of responsibility which rested upon him for so many years, now lives to see the completion of his stupendous work, and to enjoy the fame which his great achievement has won for him. Col. Roebling has not personally been upon the completed structure at all. From a house on Columbia Heights he has planned and directed the work in its details, and from a back bay-window with a telescope watched its progress. He has been greatly assisted by his wife, whose acquaintance with the whole vast work is most minute and accurate. His disease leaves him the use of all his faculties—that is plain from the result they have achieved; but forbids any unusual or long-continued exertion, under penalty of prostration. Many a man would think his enfeebled body a small price to pay for his vigorous, educated and efficient brain. To an interviewer who congratulated him on the successful termination of his great work, and suggested that this would be the last of the kind he would undertake, he is reported as replying: "I don't know. If I get well, there is lots of work to do in the world yet."

Mrs. Roebling was the first to drive over the Bridge, and found that no perceptible vibration was occasioned by the trotting of her horse.

WILLIAM C. KINGSLEY.

Mr. William C. Kingsley, who has acted as president of the Board of Bridge Trustees since the death of Mr. Murphy, is about sixty years of age, and was born in northern New York, where his father was a farmer. When about eighteen years of age, he went

WILLIAM C. KINGSLEY.

FROM A PHOTOGRAPH BY ALVA PEARSALL.

to Westmoreland County, Pa., where he taught school for a year. He then obtained a position as superintendent in the construction of a canal in western Pennsylvania, and though his predecessors had been unable to make much progress with the work owing to the wild and turbulent character of the workmen engaged on it, by his energy, determination, and tact he brought the undertaking to a successful termination. He was next engaged on the Portage railway, across the Alleghany Mountains, and in railway building in Illinois and elsewhere, always with success.

He came to Brooklyn in 1857, and soon after his arrival here, built a bridge across the Susquehanna River in Pennsylvania, and did a large share of the work on Brooklyn water and sewerage works. He also built the Fifty-ninth Street sewer in New York, and participated largely in the work on Central Park.

Mr. Kingsley was one of the first to insist upon the feasibility of a bridge across the East River, and long before the incorporation of the Bridge Company he had had plans prepared and surveys made. From the first he was confident of the success of the great enterprise, and it was by his untiring efforts that the first five million dollars devoted to the construction of the Bridge was raised, and this before a dollar had been subscribed by the cities of New York and Brooklyn. His thorough familiarity with the history and character of the great work and the intelligent zeal which he had displayed in its execution, pointed him out as the fitting successor of the late Henry C. Murphy, as president of the Board of Trustees, on that gentleman's death, in December, 1882. But although acting as President, ever since that event he has retained his former title of Vice President.

Though always influential in local politics, Mr. Kingsley has held no political position in Brooklyn. He is a man of large and varied business interests and has been identified with the Metropolitan Gas Company, and with banks and insurance companies in his city. He built the Hempstead Reservoir, and the Brooklyn Theatre, and has long been one of the largest owners of the Brooklyn Eagle.

HENRY C. MURPHY.

Henry C. Murphy was born in Brooklyn, July 3, 1810. His grandfather, Timothy Murphy, who came to this country in 1769 and settled in Monmouth County, New Jersey, was a soldier in the Revolutionary Army. John Garrison Murphy, the father of Henry C., married Clarissa Runyon, of the well-known New Jersey family of that name, and removed to Brooklyn about a year before the birth of Henry C. Mr. Murphy graduated at Columbia College in 1830, and entering upon the study of the law was admitted to the bar in 1833. He formed a partnership with the late Judge John A. Lott, and the firm of Lott, Murphy & Vanderbilt was prominent in Brooklyn for many years. Mr. Murphy became conspicuous in politics at an early age, and always took an active interest in municipal affairs. In 1834 he was delegate to the convention at Herkimer to take action in regard to the banking laws of the State, and was prominent in its deliberations. He was corporation counsel of Brooklyn in 1836 and was elected mayor in 1842, in which office he was a stanch advocate of economy and business principles. Always a Democrat in politics, he was elected to the Twenty-eighth Congress by that party before his term as mayor had expired, and distinguished himself as an advocate of tariff for revenue only. Although defeated for reëlection to the next Congress, he was returned to that body again in 1846, and during his term of service secured the passage of legislation neces-

HENRY C. MURPHY.

FROM A PHOTOGRAPH BY RAWSON.

sary to establish the dry dock at Wallabout Bay. He was a prominent member of the Constitutional Convention of 1846, and at the National Democratic Convention at Baltimore in 1852 was strongly supported for President against Franklin Pierce, who secured the nomination. In 1857 he was appointed Minister to Holland by President Buchanan, and remained at that post about three years. On returning to this country he took strong ground against secession, and energetically urged his party to yield support to the federal government in putting down the rebellion, and as chairman of the Democratic State Convention in 1862 he made an address characterized by strong Union sentiments. He also rendered efficient service in raising troops for the army. He was elected a member of the State Senate, and held that office for several terms, and was also in the Constitutional Convention of 1867. He was several times supported by his party in the Legislature for the office of United States Senator, and was also urged for the nomination for Governor. While in the Legislature he took an active part in legislation relating to Brooklyn, and it was he that drafted the first bill for the construction of the Bridge. He also had much to do with the establishment of the present water system in that city. No man did more for the improvement and development of Coney Island than Mr. Murphy, and he was president of the Brooklyn, Flatbush and Coney Island Railroad until his death. He was also an officer of the Union Ferry Co. and the Brooklyn City Railroad. There are three great enterprises with which Mr. Murphy's name will always be associated—the Dry Dock, Coney Island Improvements, and the Bridge.

Mr. Murphy was a man of decided literary tastes, and was a ready and elegant writer. His library was one of the best in the country, comprising about 5000 volumes, and being particularly rich in works relating to American history, especially that of the early colonial period. He wrote much on the latter subject, and at the time of his death was engaged on a work called "A History of Early Maritime Discovery in America." Mr. Murphy died Dec. 1, 1882.

JAMES S. T. STRANAHAN.

Mr. James S. T. Stranahan, a prominent member of the Board of Bridge Trustees, to whose energy and business talents the success of the great work is largely due, was born at Peterborough, N. Y., April 25, 1808, of New England parentage. His early life was spent on his father's farm, and his first experience as a business man was acquired in taking cattle to New York and Boston for sale. When on his father's farm, he went to the district school in winter, but later attended an academy in his native county. He also taught school for a short time, and studied civil engineering with a view to making it his profession. While still a lad he went to Albany, and engaged in the business of buying and selling wool. The late Gerrit Smith owned a large tract of land in Oneida

County, and induced Mr. Stranahan to found a manufacturing village there. This was the origin of the town of Florence, which rapidly developed into a place of several thousand inhabitants. In 1838 Mr. Stranahan was sent to the Assembly from the town.

He removed to Newark, N. J., in 1840, and became connected with railroad enterprises there, but in 1844 he transferred his residence to Brooklyn, and in 1848 became a member of the Board of Aldermen from the Sixth Ward. He ran for Mayor in 1850, but was defeated by his opponent, the late Samuel Smith. In 1854, however, he was elected to Congress, and in 1860 was a member of the Republican Convention that nominated Lincoln. In 1864

JAMES S. T. STRANAHAN.

FROM A PHOTOGRAPH BY RAWSON.

he was a Commissioner of Police in New York, and in the same year was a member of the convention that renominated Lincoln, and was also one of the Presidential electors on the Republican ticket.

During the civil war, Mr. Stranahan rendered venerable services to the Union cause. He was president of the War Fund Committee, which, together with the Woman's Relief Association, of which Mrs. Stranahan was president, organized the famous Sanitary Fair in Brooklyn, by which four hundred thousand dollars were raised for the general sanitary fund.

For many years past Mr. Stranahan has been conspicuous in almost all the great enterprises undertaken for the improvement and development of Brooklyn. The Atlantic Docks, begun in 1841, owe much to his energy. But Prospect Park is the great work with which Mr. Stranahan's name is most prominently associated. From the passage of the bill which created the Park Commission, in 1860, until very recently, Mr. Stranahan was president of that body, and it was mainly by his enterprise and perseverance that the many obstacles in the way of the undertaking were overcome.

Mr. Stranahan's services in the Board of Bridge Trustees are well known to the public; and at the present time, when people are ready to acknowledge the fidelity and zeal of those who have brought the gigantic undertaking to a successful termination, no small share of the praise and credit to which they are entitled will be accorded to Mr. Stranahan.

SETH LOW.

Mayor Seth Low, who during his short service as Mayor of Brooklyn has done much to hurry on the building of the Bridge, was born in Brooklyn about 1850, and is the youngest man who ever held that position. Mr. Low is the son of A. A. Low, the well-known merchant, and was educated at the Polytechnic Institute in Brooklyn, and at Columbia College. He was for many years a member of his father's firm, and thus acquired a thorough knowledge of those business principles which have distinguished his administration as mayor. He never held a political office until he was elected mayor, but always displayed an intelligent and active interest in muncipal affairs. His efforts in the cause of honest and economical municipal government and the elimination of partisan politics from the city government contributed in no small degree to develop among the voters of his city those sentiments which have made it so conspicuous for the independence of its citizens in local politics. Mr. Low was nominated for mayor in the fall of 1881 under peculiar circumstances. A large meeting of citizens, irrespective of party, had nominated Mr. Ripley Ropes for Mayor, and Mr. Low was one of a committee appointed by the

Young Republican Club to urge the Republican City Convention to endorse Mr. Ropes as the regular Republican candidate. Mr. Low presented the cause of the citizens very forcibly before the convention; and finally that body, though refusing to accept Mr. Ropes, nominated Mr. Low himself, much against his own protest. It was with great reluctance, and only at the urgent solicitation of his friends, that Mr. Low accepted the nomination and consented to run, Mr. Ropes withdrawing in his favor. Mr. Low

SETH LOW.

FROM A PHOTOGRAPH BY RAWSON.

declared, however, that he considered himself no party candidate, but the candidate of the citizens of Brooklyn. After a vigorous and exciting canvass Mr. Low was elected by a considerable majority, notwithstanding that his opponent was Mayor Howell, who had served two terms with eminent fidelity and success. Since entering upon the discharge of his duties Mayor Low has amply fulfilled the expectations of the citizens by whose votes he was elected, and his administration has been characterized by a high degree of intelligence, vigor, independence, and economy. By virtue of his position as mayor he became a member of the Board of Trustees of the Bridge, and energetically discharged his duties as such. During his short term of service he has done much to accelerate the completion of the great work, and has taken a leading part in all matters relating to the enterprise.

DATES OF INTEREST IN BRIDGE MATTERS.

William C. Kingsley has plans and estimates drawn, 1865.

Henry C. Murphy introduces act of incorporation in Senate of New York, January 25, 1867. Act passed, April 16, 1867.

Act transferring Bridge to the two cities passed, June 5, 1874.

Company organized, May, 1867.

John A. Roebling appointed engineer, May 23, 1867.

John A. Roebling died, July 22, 1869.

Washington A. Roebling appointed engineer, July, 1869.

Work commenced at the Brooklyn tower, January 3, 1870.

Brooklyn caisson towed to its berth, May 2, 1870.

First blocks laid on it, June 16, 1870.

Excavation under it commenced, July 10, 1870.

Fire in the Brooklyn caisson, discovered Dec. 2, 1870.

Great fire in the Brooklyn caisson discovered, December 2, 1870.

Engineer Col. Roebling partially paralyzed, December 2, 1870.

Caisson filled and finished, March 11, 1871.

New York caisson towed to its berth, October, 1871.

Filled and finished in May, 1872.

Brooklyn tower completed, May, 1875.

New York tower completed, July, 1876.

First wire rope stretched over the river, August 14, 1876.

First crossing on the wire, August 25, 1876.

Foot-bridge finished and crossed, February 9, 1877.

First cable wire run over and regulated, May 29, 1877.

Running and regulating cable wires commenced, June 11, 1877.

Last wire run over, October 5, 1878.

Strand broke loose, June 14, 1878.

Henry C. Murphy died, December 1, 1882.

Bridge opened, May 24, 1883.

OTHER STATISTICS.

Length of New York approach, 1562½ feet.
Length of Brooklyn approach, 971 feet.
Size of anchorages at base, 129 x 119 feet.
Size of anchorages at top, 117 x 114 feet.
Height of anchorages in front, 85 feet.
Height of anchorages in rear, 80 feet.
Weight of anchorages, about 60,000 tons each.
Weight of anchor plates, each 23 tons.
Length of each land span, anchorage to tower, 930 feet.
Size of Brooklyn caisson, 168 x 102 feet.
Thickness of top of Brooklyn caisson, 15 feet.
Depth of Brooklyn foundations below high-water mark, 44½ feet.
Timber and iron in caisson, 5253 cubic yards.
Concrete filled into Brooklyn caisson, 5669 cubic feet.
Size of New York caisson, 172 x 102 feet.
Thickness of top of New York caisson, 22 feet.
Depth of New York foundations below high-water mark, 78½ feet.
Weight of New York caisson, 7000 tons.
Concrete filled into New York caisson, 7000 tons.
Bolts and angle irons of New York caisson, 250 tons.
Size of towers at high-water mark, 140 x 59 feet.
Size of towers at top, 136 x 53 feet.
Height of roadway at towers, 119 feet.
Height of arches above roadway, 117 feet.
Height of towers above roadway, 159 feet.
Total height of towers above high-water, 271 feet 6 inches.
Total height Brooklyn tower, base to summit, 316 feet.
Total height New York tower, base to summit, 350 feet.
Width of opening through towers, 33 feet 9 inches.
Cubic yards of masonry in New York tower, 46,945.
Cubic yards of masonry in Brooklyn tower, 38,214.
Length of main span, tower to tower, 1595 feet 6 inches.
Height of main span above high-water mark, 135 feet 6 inches.
Number of cables, 4.
Diameter of cables, 15 feet 9 inches.
Length of each cable, 3578 feet 6 inches.
Number of wires in each cable, 5434.
Number of wires in the four cables, 21,736.

Total length of wire in each cable, unwrapped, 3515 miles.

Total length of wire in the four cables, unwrapped, 14,060 miles.

Weight of wire, one pound to nearly 11 feet.

Greatest length of cable wire run in one day, 88⅝ miles.

Length of wrapping wire on each cable, 243 miles 943 feet.

Weight of 4 cables, wrapped, 3588½ tons.

Ultimate strength of each cable, 12,200 tons.

Greatest load that can come on one cable, 3000 tons.

Number of suspenders from each cable, main span, 208.

Number of suspenders from each cable, land spans, 86.

Strength of a single suspender, 70 tons.

Greatest weight in a single suspender, 10 tons.

Number of postbands, each land span, one cable, 35.

Number of overfloor stays, 432.

Total length of bridge, 5989 feet.

Full width of flooring, 85 feet.

Grade of roadway, 3¼ feet in 100.

Natural elevation above high-water, Brooklyn terminus, 61½ feet.

Natural elevation above high-water, New York terminus, 38½ feet.

Weight of the whole suspended structure, 6740 tons.

Maximum weight to be got in it, 1380 tons.

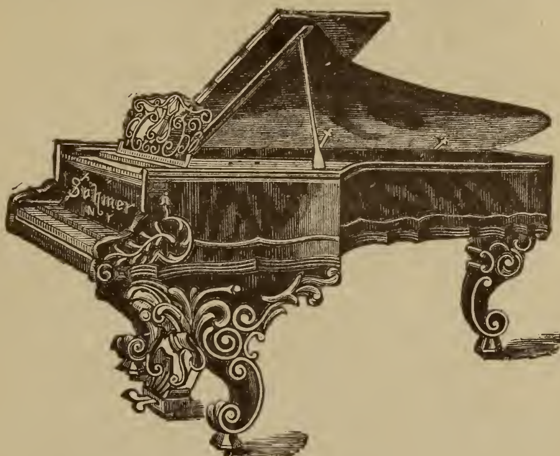
Maximum weight of roadway and traffic in cables, 6920 tons.

Maximum weight of roadway and traffic on stays, 1190 tons.

"SOHMER"

Grand, Square & Upright Pianos.

ANOTHER GREAT VICTORY
FOR THE "SOHMER" PIANO
AT THE



EXHIBITION, 1881 AND 1882,
MONTREAL. EXHIBITION 1876,
PHILADELPHIA.

Messrs. SOHMER & CO. take great pleasure in announcing to their numerous friends and patrons that, after a severe and critical test by the Judges of Musical Instruments—in which nearly all the prominent and leading manufacturers of the United States and Canada were represented—they have conferred upon "SOHMER & CO." the highest honors, viz.: ***First Prize Diploma of Honor, and Honorable Mention, and a Diploma of Special Excellence for BABY GRANDS, which was the highest and only one given.***

Messrs. SOHMER & CO. will strive to merit the confidence intrusted them by the trade, and will continue their strenuous efforts to excel in all the various styles of Pianos manufactured.

SOHMER & CO., 149 to 155 E. 14th St., New York.

OTIS PARLOR BED.

Latest---Best---Cheapest.

TURNS DOWN WIDTH INSTEAD OF LENGTH.

Entirely New Principle.

PRICES FROM $20 TO $200.

OTIS PARLOR BED CO., 114 W. 14th St., near 6th Av., N. Y.